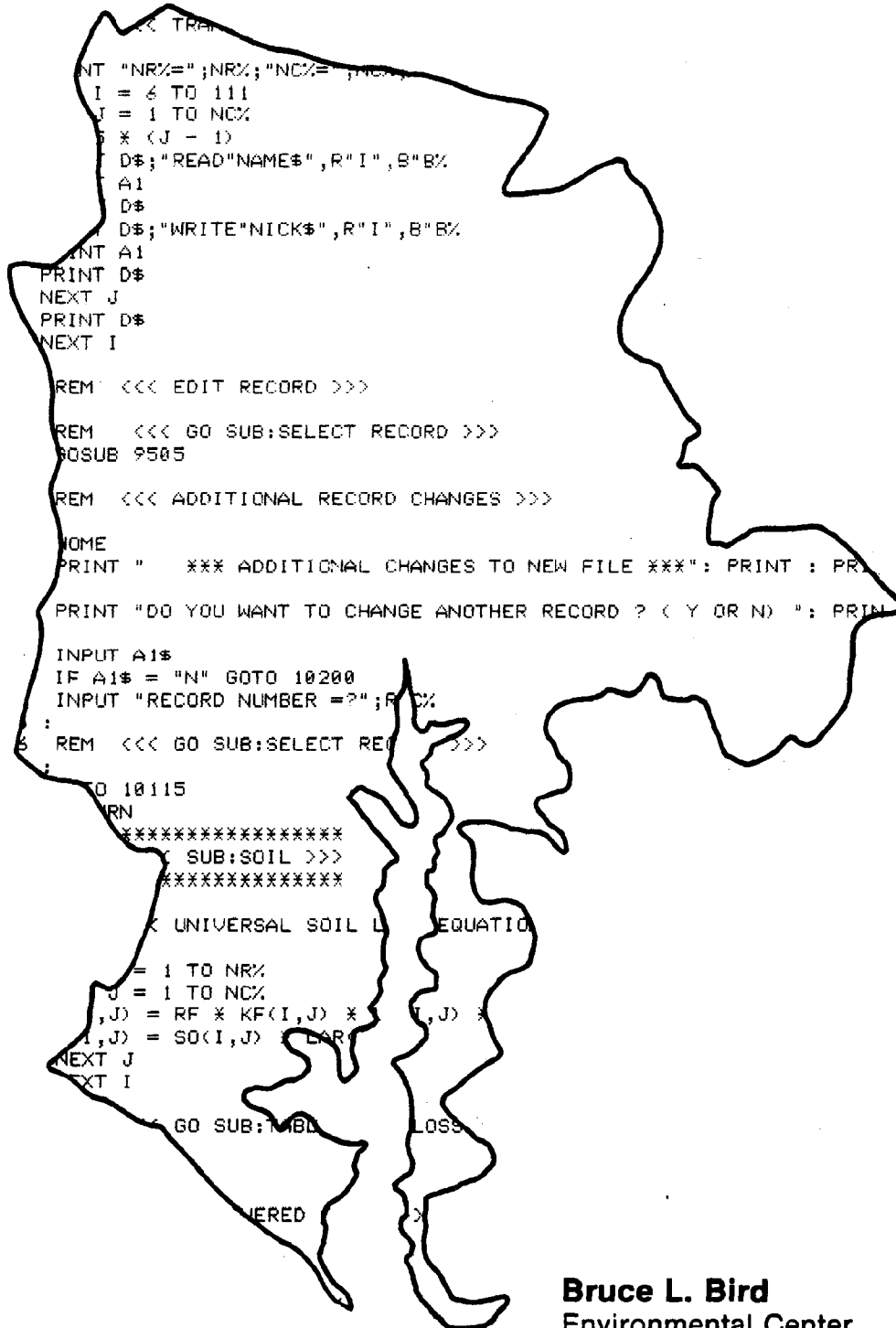


REC
REC'D. 8/1/84

CHURCH CREEK WATERSHED

An illustration of the application of microcomputers for estimating the effects of land use changes on nutrient and pollutant loading.

Mid-Dept of Natural Resources
HD211.M3B57 1983



HD
211
.M3
B57
1983



Bruce L. Bird
Environmental Center
Anne Arundel Community College
K. Marlene Conaway
Office of Planning and Zoning
Anne Arundel County

CHURCH CREEK WATERSHED

An illustration of the application of microcomputers
for estimating the effects of land use changes on
nutrient and pollutant loading

Bruce L. Bird

Environmental Center

Anne Arundel Community College

Arnold, Maryland 21012

K. Marlene Conaway

Office of Planning and Zoning

Anne Arundel County

Annapolis, Maryland 21404

June

1983

ACKNOWLEDGMENTS

The authors express their thanks to Hermann Gucinski who contributed some of the initial ideas that led to this work, and furnished helpful comments on the manuscript. Doris Anderson, Sally Barba, and Ed Sparks of Media Services at AACC drew the graphics. Nancy Matthews planimetered the land use areas. Meg Munro, librarian at EPA, helped in locating needed references. Ginger Klingelhoef-er-Ellis, Penny Chalkley, Tom Ervin, and Michael Cirino, at the Office of Planning and Zoning, gave technical assistance. Martha Wooten assisted by typing and editing this report.

This study was partially funded through a grant from the Maryland Coastal Zone Management Program.

TABLE OF CONTENTS

| | Page |
|--|------|
| Acknowledgments | i |
| List of Tables | iii |
| List of Figures | iv |
| Executive Summary | vi |
| I. Introduction | 1 |
| II. Watershed Computer Models | 3 |
| III. WATER SCREEN | 6 |
| Personnel Requirements | 6 |
| Machine Requirements | 6 |
| Program Logic | 7 |
| Algorithms Used in WATER SCREEN | 8 |
| A. Modified Universal Soil Loss Equation | 8 |
| B. Nitrogen Loading Function | 10 |
| C. Phosphorous Loading Function | 11 |
| D. Organic Matter Loading Function | 12 |
| E. Loading Factors | 13 |
| IV. Church Creek Watershed | 14 |
| Introduction | 14 |
| Description | 14 |
| Input Parameters for WATER SCREEN | 25 |
| Comparison of MUSLE with Loading Factor Approach | 32 |
| Nutrient and Pollutant Discharge to Church Creek | 39 |
| V. Impact of Nutrient and Pollutant Loadings on Church Creek | 54 |
| VI. Discussion and Recommendations | 64 |
| References | 67 |
| Appendix A - WATER SCREEN logic and comments | 74 |
| Appendix B - WATER SCREEN program listing | 76 |

LIST OF TABLES

| | Page |
|--|------|
| 1. 1974 Land Use Areas | 22 |
| 2. 1981 Land Use Areas | 23 |
| 3. General Development Plan Land Use Areas | 24 |
| 4. Parameter Values for Church Creek Watershed | 26 |
| 5. LS Parameter Values for Church Creek Watershed | 27 |
| 6. Loading Factors (lbs/acre/year) Selected for Church Creek Watershed | 31 |
| 7. Measured Loadings from Rhode River Watershed | 37 |

LIST OF FIGURES

| | Page |
|---|------|
| 1. Location of Church Creek Watershed | 15 |
| 2. Church Creek Subwatersheds | 16 |
| 3. Color Code for Land Use Maps | 17 |
| 4. 1974 Land Use | 18 |
| 5. 1981 Land Use | 19 |
| 6. General Development Plan Land Use | 20 |
| 6'. Problems in Estimating Average LS Factor | 29 |
| 7. Comparison of MUSLE and Loading Factor Estimates - Sediment | 33 |
| 8. Comparison of MUSLE and Loading Factor Estimates - Total Nitrogen | 34 |
| 9. Comparison of MUSLE and Loading Factor Estimates - Total Phosphorous | 35 |
| 10. Total Sediment Loading by Land Use | 41 |
| 11. Total Nitrogen Loading by Land Use | 42 |
| 12. Total Phosphorous Loading by Land Use | 43 |
| 13. BOD Loading by Land Use | 44 |
| 14. Lead Loading by Land Use | 45 |
| 15. Zinc Loading by Land Use | 46 |
| 16. Pollutant Loading by Subwatershed (Sediment and Nitrogen) | 48 |
| 17. Pollutant Loading by Subwatershed (Phosphorous and BOD) | 49 |
| 18. Pollutant Loading by Subwatershed (Lead and Zinc) | 50 |
| 19. Total Pollutant Loading From Church Creek Watershed (Sediment, Nitrogen, Phosphorous) | 51 |

LIST OF FIGURES (continued)

| | Page |
|--|------|
| 20. Total Pollutant Loading From Church Creek Watershed (BOD, Lead, Zinc) | 52 |
| 21. Church Creek Bathymetry | 56 |
| 22. Church Creek in Cross Sections | 57 |
| 23. Church Creek Longitudinal Profile | 58 |

EXECUTIVE SUMMARY

Land use planners must channel demands for land use within a watershed so that a proper balance can be maintained between an individual's right to develop his land versus society's obligation to preserve the environment for future generations. This report discusses one approach that land planners may wish to use to help them achieve a reasonable distribution of land use.

A computer program, WATER SCREEN, has been written for the Apple II microcomputer. This program can be used by land use planners to estimate the amounts of sediment, nitrogen, phosphorous, BOD, lead, and zinc that are produced by various land use patterns within a watershed. Both a modified universal soil loss equation and a loading factor method are used in the program to estimate nutrient and pollutant loadings.

The 1200 acre Church Creek watershed was analyzed with the WATER SCREEN program. A comparison of the Modified Universal Soil Loss Equation approach to the loading factor method for forest and agricultural land use did not give good agreement on estimated loadings. This is attributed to the simplified method of relating nutrient and pollutant loadings to sediment loadings used with the Modified Universal Soil Loss Equation approach.

The loading factor method was used to arrive at estimated loadings from the Church Creek watershed for the following development patterns: all forest predevelopment, 1974 land utilization, 1981 land utilization, and a hypothetical development pattern for study purposes based on the present general development plan map (GDP). Between 1974 and 1981 there

has been a small decrease in sediment loading from the watershed due to a change in farming practices from conventional to minimum tillage. Total nitrogen and total phosphorous loadings have remained unchanged, while biochemical oxygen demand (BOD), lead, and zinc have increased 25% because of increased commercial and high density residential land use.

By taking the ratio of loadings produced by the 1981 land utilization pattern to the loadings produced assuming the watershed was originally covered with forest, it was estimated that by 1981 yearly sediment loadings had increased by a factor of 10, total nitrogen by 2, total phosphorous by 7, BOD by 4.5, lead by 60, and zinc by 40. If the watershed were to develop without any controls as hypothesized then all of these loading ratios would double. These estimates are probably conservative because they do not account for nutrient and pollutant loadings that occur during road and building construction. A rough estimate of the lead loading produced by vehicle traffic within the Church Creek watershed indicates that this may be a significant source of pollution within the watershed.

At the present time scientific knowledge does not allow a definitive statement as to the effect of the estimated loadings on the water quality of Church Creek. However, a method is suggested for using pollutant loading ratios based on the model results and correlated with desired estuarine health as a guideline for planning land use within a watershed.

It is suggested that additional monitoring of single use sub-watersheds be undertaken by appropriate agencies. Also the effect of best management practices on impervious areas needs further study. Local jurisdictions should consider use of WATER SCREEN for the evaluation of watersheds under heavy development pressure. The contribution of vehicle traffic to nutrient and pollutant loadings in small watersheds should be investigated.

I. INTRODUCTION

To understand the sources of excess nutrients and pollutants that enter a stream or tidal tributary it is necessary to look at all inputs: point source, non-point source, and atmospheric. Unfortunately, a thorough environmental analysis requires extensive spatial and temporal monitoring in order to adequately characterize inputs, dynamics, and sinks of the primary nutrients and pollutants. Add to this the variety and number of physical, chemical, and biological variables involved and one can then appreciate the difficulty that water quality managers face when, with limited funds and personnel, they are charged with the responsibility of protecting the water quality of a stream or tidal tributary.

Land use planners must channel demands for land use within a watershed so that a proper balance can be maintained between an individual's right to develop his land versus society's obligation to preserve the environment for future generations. This report discusses one approach that land planners may wish to use to help them achieve a reasonable distribution of land use.

The objectives of this work were the following:

1. Develop a computer program, WATER SCREEN, suitable for use with a microcomputer, that utilizes currently available algorithms for the calculation of sediment, nutrient, and pollutant loadings as a function of land use.
2. Illustrate the use of this computer program by application to the Church Creek watershed for 1974 and 1981 land use patterns. Compare these results with those obtained

assuming the watershed was all forest and with hypothetical land use for the watershed based on the 1978 General Development Plan.

In addition, some approximate calculations are given for estimating the flushing time of Church Creek. The question of how much nutrient and pollutant loading Church Creek can absorb without degradation in water quality is also discussed.

This report is divided into five sections. The first section is a discussion of the range of computer models available that deal with pollutant loadings and where the program WATER SCREEN fits within this framework. The second section discusses the algorithms used in WATER SCREEN. The third section illustrates the application of WATER SCREEN to the Church Creek watershed. The land use patterns for the watershed are presented and the parameter values chosen for use in WATER SCREEN are listed. The loadings are given for sediment, total nitrogen, total phosphorous, BOD, lead, and zinc for the four land use patterns: all forest, 1974 land use, 1981 land use, and hypothetical land use based on the General Development Plan (GDP). The fourth section discusses calculations of flushing time and the impact of nutrient and pollutant loadings on Church Creek. The final section gives a summary of the findings for the Church Creek watershed and suggestions for further work. Technical details for using WATER SCREEN are given in Appendix A, while a complete listing of WATER SCREEN is given in Appendix B.

II. WATERSHED COMPUTER MODELS

Because of the high cost of carrying out sufficient spatial and temporal sampling to adequately characterize even a small watershed, other alternatives have been sought. A great deal of effort has been devoted to the development of detailed computer models that can be used to simulate the water, nutrient, and pollutant transport within a watershed. These detailed models include processes with short time scales so that the hydrology can follow effects of a single storm event or follow variations in daily rainfall. The models then relate sediment, nutrient, and pollutant transport to the hydrologic simulation.¹⁻⁷

The mathematical equations used in these detailed models to describe the individual processes occurring within the natural system contain numerical coefficients that must be determined by comparing the model calculations with at least three years of watershed data. Once these coefficients are determined two additional years of data are needed to verify that the predictions of the model agree with measured values.⁸ Thus a minimum of five years of watershed data is needed to develop a detailed model that would be considered reliable.

The development of a detailed model is expensive. Most models that are now available have been developed primarily with federal support.¹ These detailed models also need computers that are large enough to handle the computational and memory requirements. This requires access to a main frame computer and personnel with the required technical background to run the model.

Because most local agencies do not have the resources required for proper application of the detailed models, a further simplification

has been made. Watersheds with sufficient data to calibrate and verify a model are used to generate average loading factors for nutrients and pollutants and for different land uses.⁹⁻¹¹ A loading factor gives the average amount of pollutant produced by a given land use in terms of pounds per acre per year. If the watershed from which the loading factors are derived is similar to the watershed of local interest, then an estimate of nutrient and pollutant loadings can be made once the land use patterns of the local watershed are determined. This is one of the approaches used in WATER SCREEN.

An alternative method for estimating nutrient and pollutant loadings is based on the Modified Universal Soil Loss Equation (MUSLE). The USLE was developed by soil scientists to estimate soil loss from agricultural fields. It was later modified by the addition of a sediment delivery factor so that the amount of soil that reaches a natural water body can be estimated. Nutrient and pollutant loadings can be related to the amount of delivered sediment.¹²⁻¹⁴ This approach is also used in WATER SCREEN to allow comparison with the loading factor method for forest and agricultural land use.

The modeling methods discussed here avoid the high cost of adequate spatial and temporal sampling of a large number of physical, chemical, and biological variables. As a result all of these methods produce estimates of pollutant loadings. In addition, the simplified approaches work with spatially and temporally averaged quantities. Hence one can not expect these less costly approaches to predict the exact value of any one particular measurement. However, they can give some insight into what effect land use changes will have and perhaps

indicate areas of concern that should be investigated in greater detail.

Some may be tempted to argue that instead of spending time and money on estimates of pollutant loadings produced in a watershed one could better utilize resources by measuring a few selected variables. We suggest that because of the spatial and temporal distributions of the system the results of a few measurements can produce as much, if not more, uncertainty in average values as that obtained from calculated estimates. There is no simple solution. Perhaps the use of simplified model estimates to indicate selected measurements that should be taken is the most realistic approach for water quality managers with funding and personnel limitations.

III. WATER SCREEN

The computer program WATER SCREEN uses input parameters provided by the operator to calculate nutrient and pollutant loadings from a watershed. In the following sections personnel requirements, computer hardware, program logic, and loading equations for this program are described. Details for running the program are given in Appendix A and the program is listed in Appendix B.

Personnel Requirements

A person with minimum computer experience can run WATER SCREEN. A person who has run some commercially available programs on a microcomputer should have no difficulty. A knowledge of BASIC is not required; however, some acquaintance with BASIC on the level of Apple II User's Guide, by Poole, would allow the operator to take full advantage of the logical structure and data file generating capabilities of the program. The user need not be an expert in hydrology or ecology, but he/she should become familiar with the material covered in references 9 and 12.

Machine Requirements

WATER SCREEN has been written and run on an Apple II microcomputer system with 48K of memory. The system consists of a single disk drive and a NEC PC-8023A printer connected to the Apple II using the Orange Micro Grappler interface. As written, for six subwatersheds, the program without REMARK statements occupies 29K of memory. It is estimated that a watershed with up to 20 subwatersheds could be run before one would run out of memory on a 48K machine. If more subwatersheds were needed, the watershed could be separated into smaller sections and then

each section evaluated using the program. While the program is written in Applesoft BASIC it could readily be modified for use on other machines using the appropriate translations. The printer commands are listed in separate subroutines and can be easily modified for other printers if needed. Modifications of the file commands used to store input data on disk would require the most effort.

Program Logic

WATER SCREEN can easily be modified to accommodate changes that may be proposed to the algorithms now used or to incorporate new algorithms. The program consists of three major sections: (1) data file creating, reading, and editing; (2) calculation of pollutant and nutrient loading using the modified universal soil loss equation (MUSLE) and algorithms described by Zison et al¹² for nitrogen, phosphorous and organic matter; (3) calculation of nutrient and pollutant loading using loading factors developed by the Northern Virginia Planning District Commission (NVPDC) in their extensive study of the Occoquan River Basin.⁹

The data file part of the program asks the user to input factors for the MUSLE and for soil and rainfall information needed to calculate nitrogen, phosphorous, and organic loadings. Loading factors for various categories of land use must also be input to the program. Much of this information is requested by subwatershed so that variations within the watershed can be accommodated.

For the Church Creek watershed with six subwatersheds it takes about twenty minutes to input all the required data. The program stores this data on a disk file where it can later be recalled and edited if

desired. The run time of the program depends upon the number of sub-watersheds selected and the speed of the printer. The printout of the results from the Church Creek watershed takes about twenty minutes using an eighty characters per second printer. Subtotals and totals are printed by subwatershed, land use, and pollutant type.

The file editing feature makes it possible to quickly see the sensitivity of the calculation to changes in the value of a parameter, such as slope or loading factor, by running the program, using the editing feature to change the desired parameter, and then rerunning the program.

Algorithms Used in WATER SCREEN

A. Modified Universal Soil Loss Equation

Agricultural and soil scientists have been concerned for decades with the problem of controlling soil loss from farm land. The universal soil loss equation was developed to estimate soil loss from a field and to predict the effects of crop rotation, management practices, etc.¹⁵

The USLE has the form:

$$Y(S)_E = A \cdot R \cdot K \cdot L \cdot S \cdot C \cdot P$$

where

$Y(S)_E$ = soil loss due to surface erosion (tons/year)

A = area of field (acres)

R = rainfall factor, indicates the erosion potential of average annual rainfall (R unit)

K = soil-erodibility factor (tons/acre/R unit)

L = slope-length factor (dimensionless ratio)

S = slope-steepness factor (dimensionless ratio)

C = cover factor (dimensionless ratio)

P = erosion control practices factor (dimensionless ratio)

The U. S. Department of Agriculture has carried out extensive experimental studies on fields located throughout the United States. From these studies accepted values for the factors in the USLE have been tabulated. Local values are obtainable from handbooks published by the Soil Conservation Service.¹⁶ As has been pointed out by various authors, the USLE only predicts the soil lost from a field. It does not estimate the actual amount of soil that is delivered to a stream channel. In order to estimate this an additional factor, the sediment delivery ratio, is needed.¹⁷

To estimate the amount of soil delivered to a stream the modified universal soil loss equation (MUSLE) is used. The MUSLE has the form:

$$Y(S)_D = Y(S)_E S_D$$

where

$Y(S)_D$ = soil delivered to stream channel (tons/year)

$Y(S)_E$ = soil lost from field (tons/year)

S_D = sediment delivery ratio (dimensionless ratio)

The sediment delivery ratio is probably the most difficult factor in the MUSLE to estimate with any degree of reliability. Its value in different watersheds has been obtained by observing the silting rate of dams. Obtained this way it accounts not only for field losses but also all other erosion processes, such as stream channel erosion, which are not accounted for by the USLE.

It is generally accepted that the soil lost from an individual field can be reliably estimated using appropriate local values for the factors in the USLE. However, it is quite another matter to

reliably estimate the sediment loading from a watershed composed of many fields with varying slopes, ground cover, distance from stream channel, etc. For example, it is not clear how to handle fields with concave slopes. Soil lost from one part of a field may redeposit in another part of the same field or in another part of the watershed.¹⁸

The MUSLE has been applied primarily to agricultural and forest land although some work has been done to extend it to residential land use. In this report the MUSLE will only be applied to forest and agricultural land use.

B. Nitrogen Loading Function

Zison et al.¹² point out that the movement of nitrogen compounds within an ecosystem is complex and still not thoroughly understood. For an estimate of the amount of total nitrogen produced by runoff and erosion, excluding leaching losses, they suggest the following expression:

$$Y(NA) = f_N Y(NT)_E + Y(N)_{Pr}$$

where

$Y(NA)$ = total available nitrogen (lbs/year)

f_N = ratio of available to total nitrogen
in sediment (dimensionless)

$Y(NT)_E$ = total nitrogen loading from erosion (lbs/year)

$Y(N)_{Pr}$ = stream nitrogen loading from precipitation
(lbs/year)

$Y(NT)_E$ is found from the expression:

$$Y(NT)_E = 20 Y(S)_D C_S(NT) r_N$$

where

$Y(S)_D$ = soil delivered to stream channel (tons/year)

$C_S(NT)$ = total nitrogen concentration in soil (g/100g)

r_N = nitrogen enrichment ratio

The factor of 20 takes into account the units used in this equation.

$Y(N)_{Pr}$ is found from the expression:

$$Y(N)_{Pr} = A \frac{Q(OR)}{Q(Pr)} N_{Pr} b$$

where

A = area (acres)

$Q(OR)$ = overland flow from precipitation (in/year)

$Q(Pr)$ = total amount of precipitation (in/year)

N_{Pr} = nitrogen loading in precipitation (lb/acre/year)

b = attenuation factor

Zison et al.¹² discuss the methods of evaluation of the parameters in the nitrogen loading function.

C. Phosphorous Loading Function

A great deal of confusion still exists about the proper terms for describing the various physical and chemical states of phosphorous. There is also some disagreement about the effectiveness of chemical extraction procedures to selectively remove a particular phosphate

form from soils.¹⁹ Because of these uncertainties the values of the parameters used in the loading function for phosphorous are only rough approximations. Zison et al.¹² suggest that based on the soil erosion transport mechanism the loading function for phosphorous should have the form:

$$Y(PA) = 20 \cdot f_P \cdot Y(S)_D \cdot C_S(PT) \cdot r_P$$

where

$Y(PA)$ = loading of available phosphorous (lbs/year)

f_P = ratio of available phosphorous to total phosphorous (dimensionless)

$Y(S)_D$ = soil delivered to stream channel (tons/year)

$C_S(PT)$ = total phosphorous concentration in soil (g/100g)

r_P = phosphorous enrichment ratio

Zison et al.¹² discuss the methods for determining the parameters in the phosphorous loading function.

D. Organic Matter Loading Function

Zison et al.¹² also suggest a loading function for organic matter of the form:

$$Y(OM)_E = 20 \cdot C_S(OM) \cdot Y(S)_D \cdot r_{OM}$$

where

$Y(OM)_E$ = organic loading (lbs/year)

$C_S(OM)$ = organic matter concentration in soil (g/100g)

$Y(S)_D$ = soil delivered to stream channel (tons/year)

r_{OM} = enrichment ratio for organic matter in eroded soil

Procedures for determining the values of the parameters in the organic loading function are given by Zison et al.¹²

E. Loading Factors

During the last seven years field and detailed modeling studies of non-point pollution from small watersheds with one predominant land use have been funded by the Water Resources Planning Board, Washington Council of Governments, and by the Environmental Protection Agency Chesapeake Bay Program. The modeling studies were carried out by the Northern Virginia Planning District Commission (NVPDC). The earlier watershed studies on the Occoquan River Basin were done by personnel from the Civil Engineering Department, Virginia Polytechnic Institute. Later watershed measurements were done in the Ware River Basin (southeastern Virginia), Pequea Creek Basin (Lancaster, Pennsylvania), Patuxent River Basin (western shore of Chesapeake Bay), and Chester River Basin (eastern shore of Chesapeake Bay). These measurements were done by groups from Virginia Institute of Marine Science, U. S. Geological Survey, and State of Maryland, respectively.²⁰⁻²³

As a result of this work non-point pollution loading factors have been generated which can be used to estimate loadings produced in a watershed by using the equation:

$$Y(X) = \sum_{i=1}^N F_i(X) A_i$$

where

$Y(X)$ = loading of pollutant X (lbs/year)

$F_i(X)$ = loading factor for pollutant X
and land use i (lbs/acre/year)

A_i = area of land use i (acres)

In this report we have used the loading factors given in reference 9.

A recalibration of these factors has recently been reported.¹¹

IV. CHURCH CREEK WATERSHED

Introduction

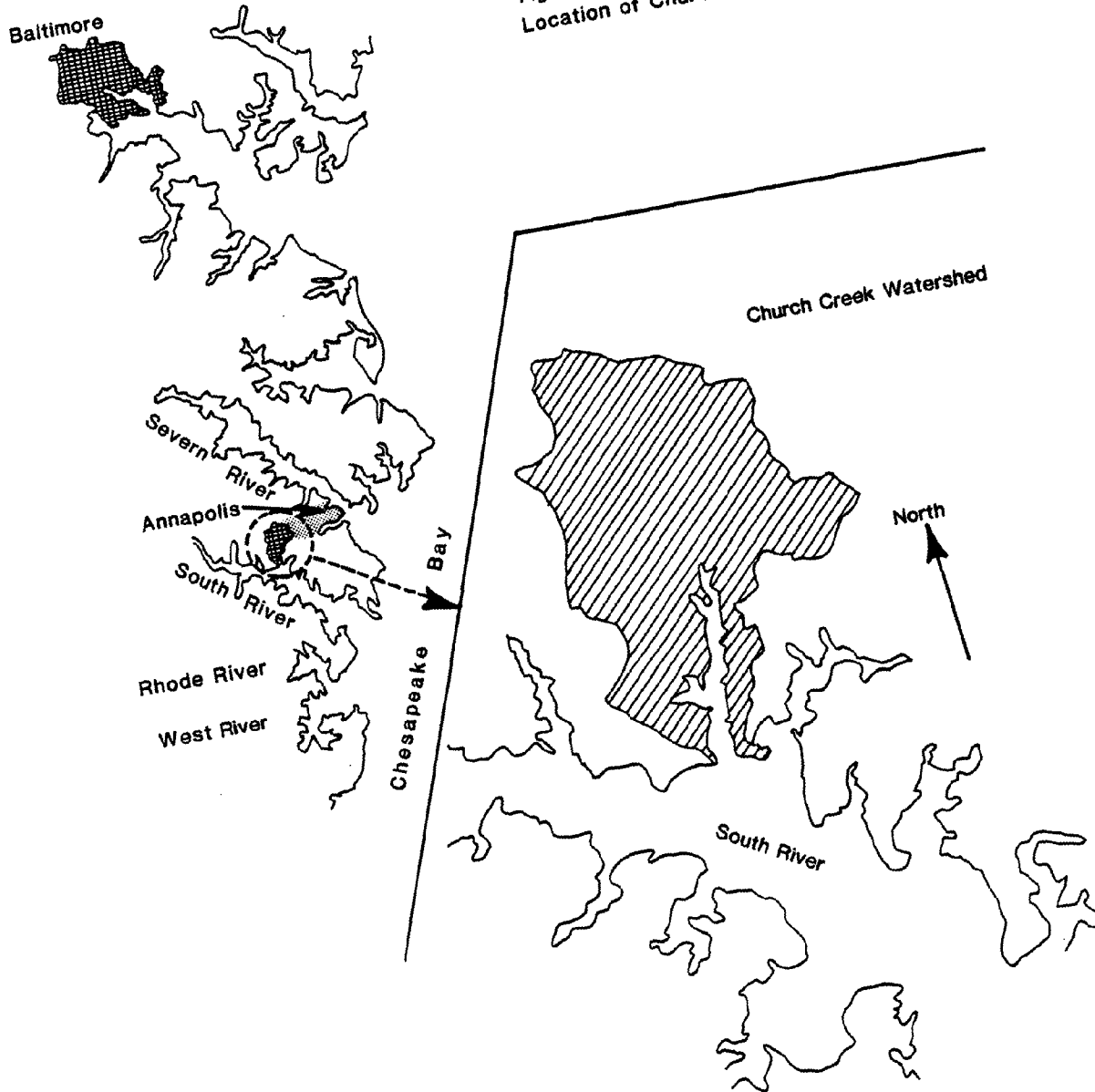
A small watershed was selected to demonstrate the application of the WATER SCREEN program. In this section we describe the Church Creek watershed, land use patterns of this watershed in 1974, 1981, and a hypothetical development pattern based on the General Development Plan (GDP), and the choice of input parameters for WATER SCREEN. We then compare the results of the modified universal soil loss equation (MUSLE) method with the loading factor approach for forest and agricultural land use, and discuss the estimated loadings for all forest, 1974, 1981, and GDP land use patterns.

Description

Church Creek is located just south of Annapolis, Maryland. It is a mile-long tidal tributary of South River, which is a subestuary of the Chesapeake Bay. (See Figure 1.) The watershed has an area of 1200 acres. The soil type within the watershed is predominately Mornmouth loamy sand with some Collington fine sandy loam.²⁵ Typical land slopes are in the 0 to 10% range with the higher slopes on land close to the shores of the creek.

For purposes of analysis the watershed was divided into six sub-watersheds based on water drainage patterns. These sub-watersheds are indicated in Figure 2. The land use patterns that existed in 1974 and 1981 are shown in Figures 4 and 5, using the color code shown in Figure 3. A hypothetical land use pattern based under the present General Development Plan is shown in Figure 6. It should be emphasized that this

Figure 1
Location of Church Creek Watershed



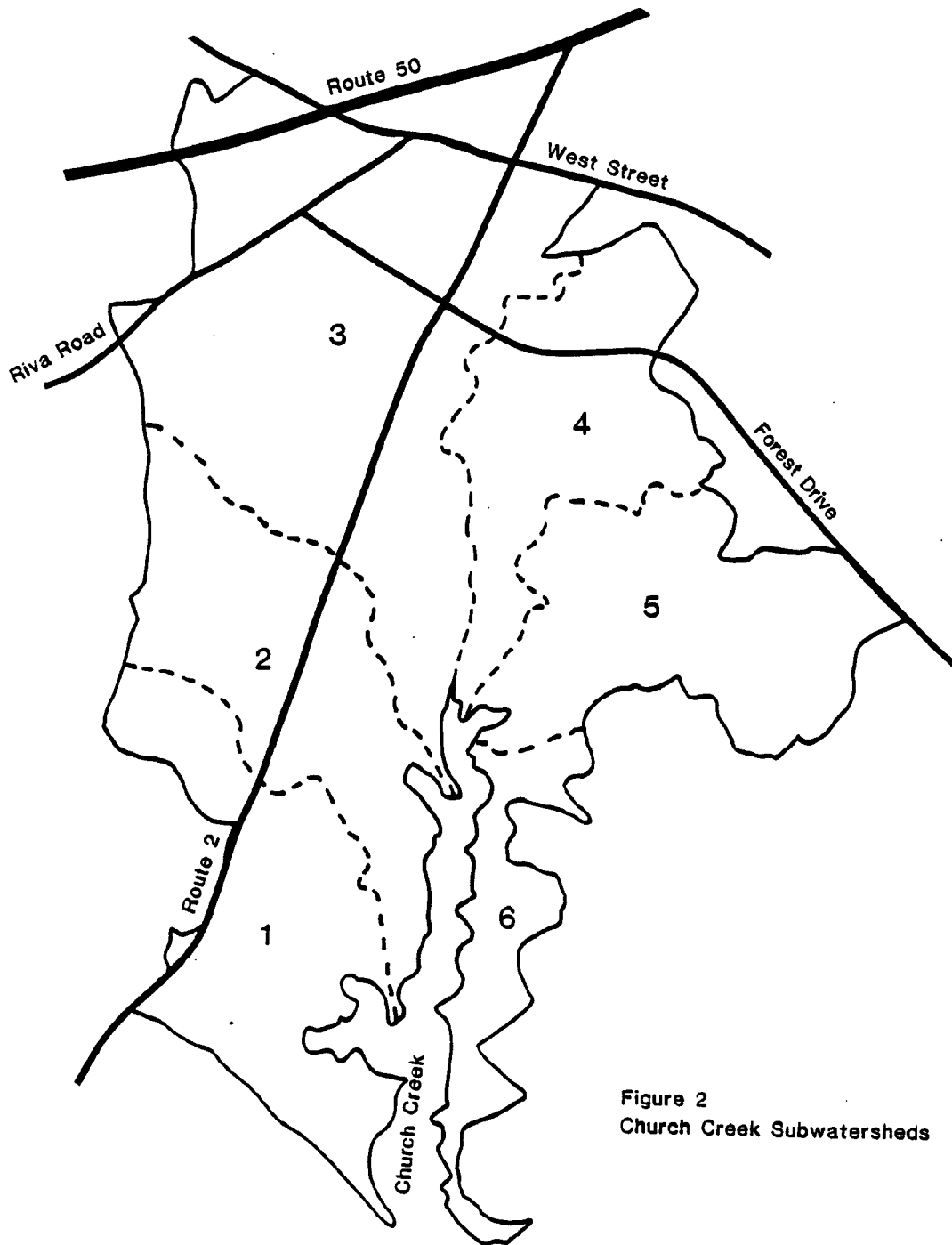


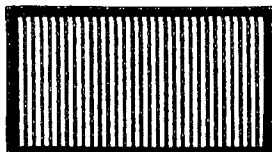
Figure 2
Church Creek Subwatersheds



FOREST



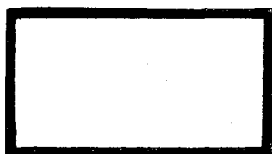
LOW/MEDIUM
DENSITY
2-5 DU/ACRE



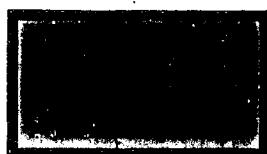
PASTURE



MEDIUM DENSITY
5-10 DU/ACRE



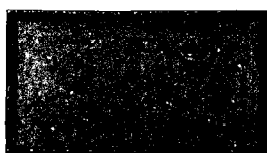
HAYFIELD



HIGH DENSITY
10 OR MORE
DU/ACRE



CROPLAND



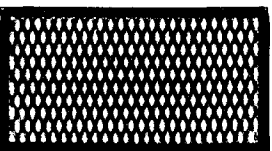
COMMERCIAL-
GENERAL



MINIMUM TILLAGE



COMMERCIAL-
UNDER
CONSTRUCTION



IDLE



INDUSTRIAL PARK



LOW DENSITY
1/2-1 DU/ACRE

Figure 3
Color Code for Land Use Maps

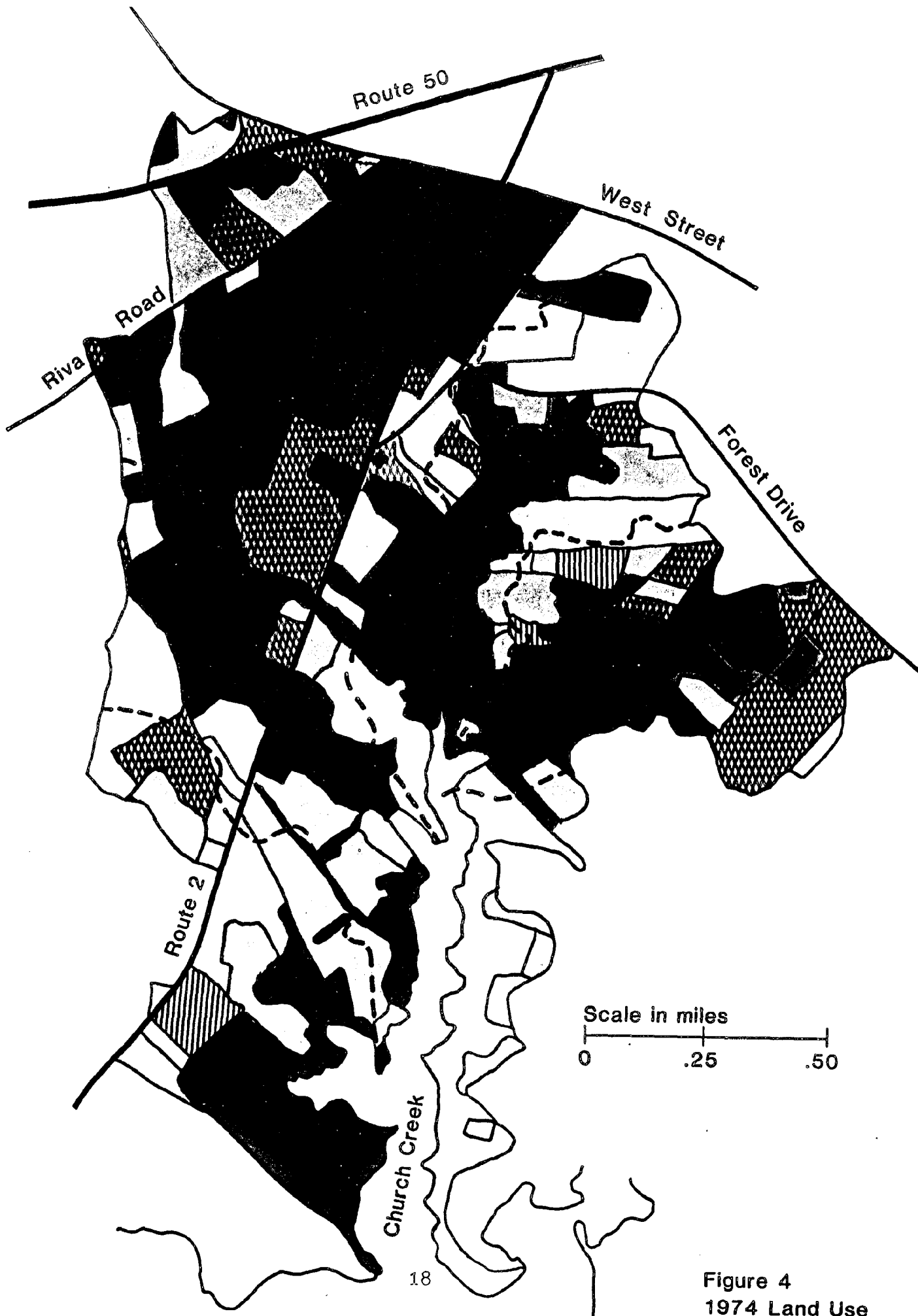


Figure 4
1974 Land Use

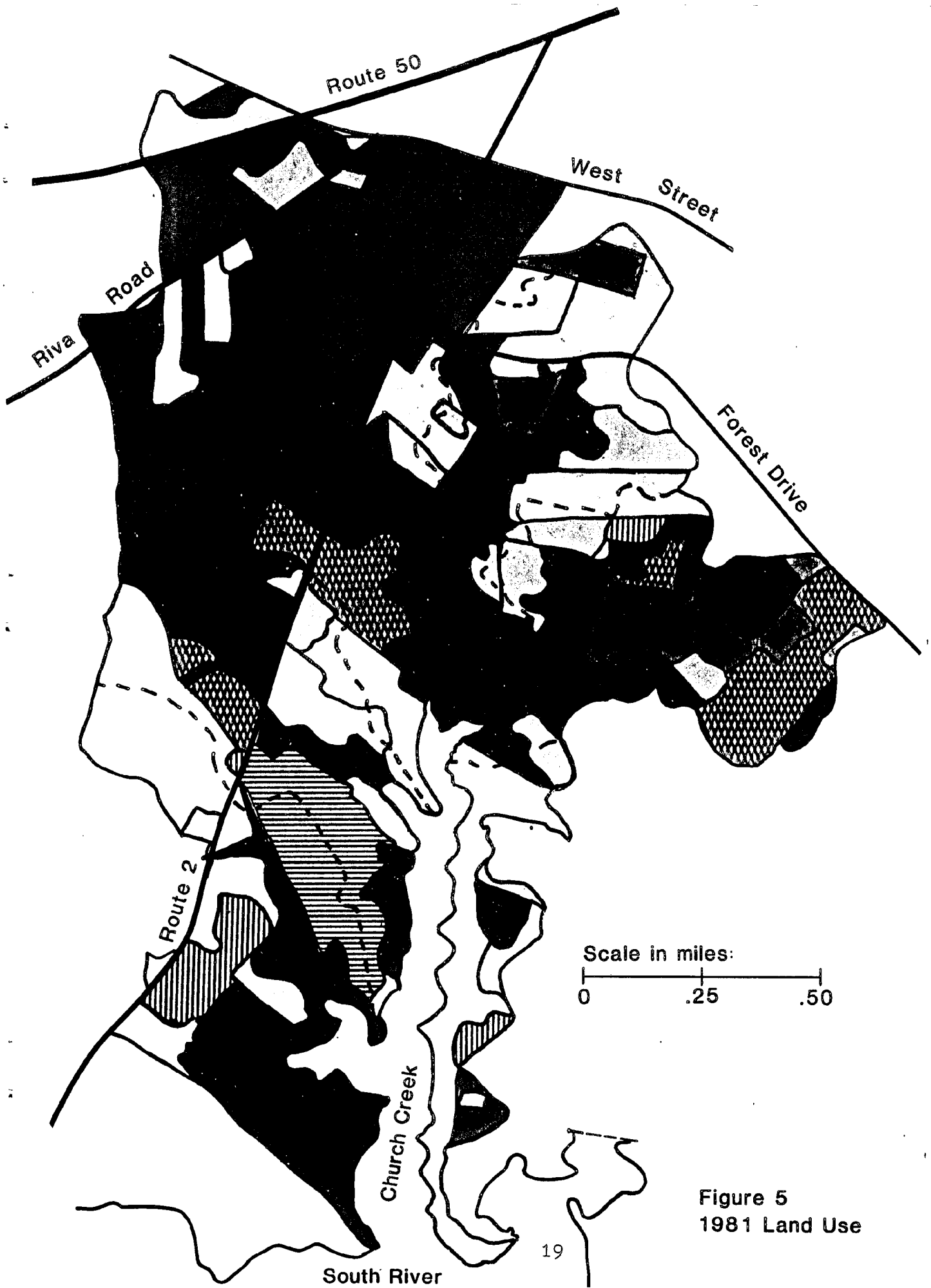


Figure 5
1981 Land Use

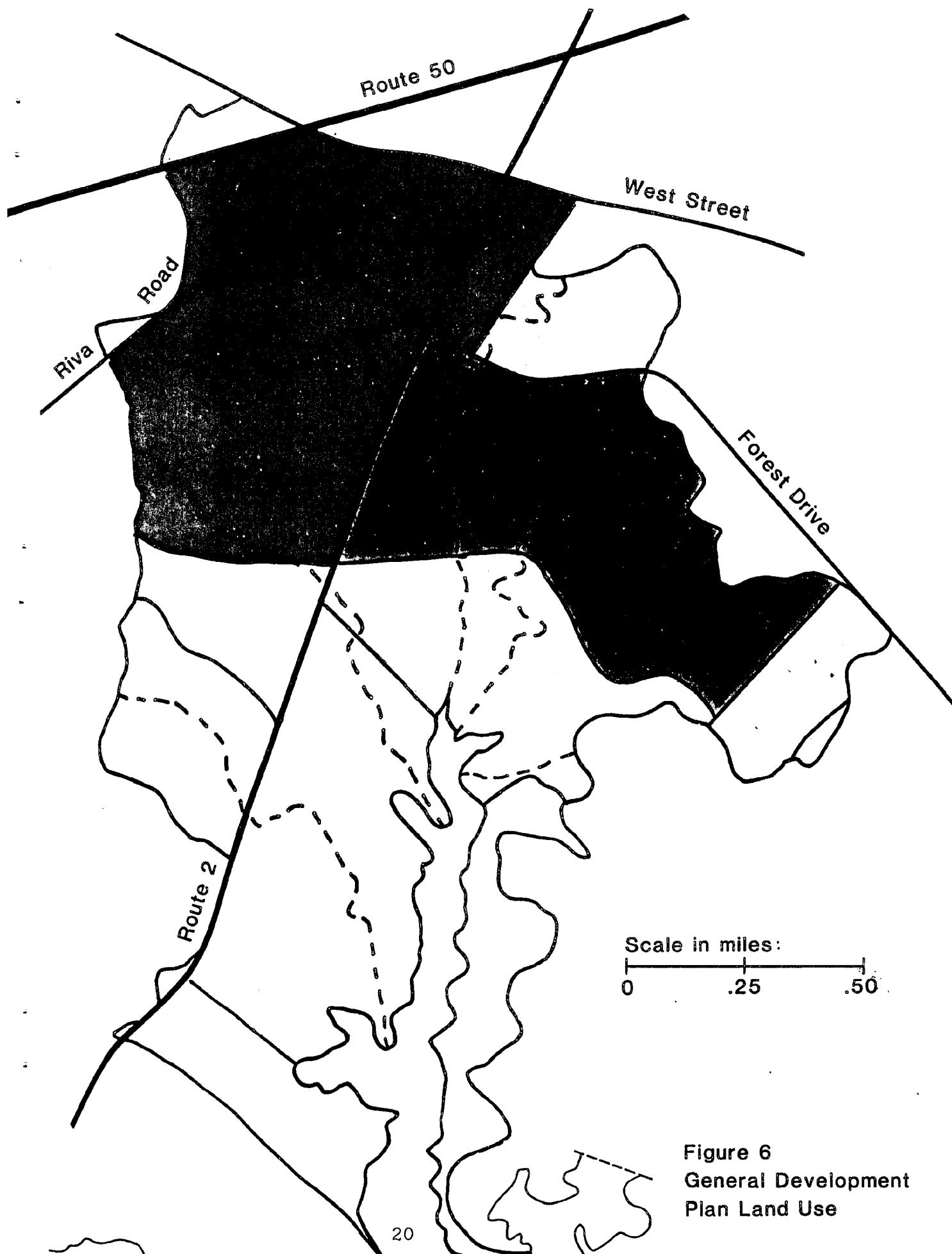


Figure 6
General Development
Plan Land Use

projected land use is not possible because of existing development patterns and regulatory controls. It is presented as an extreme to which present land use can be compared. Tabulated values for 1974, 1981, and GDP land use areas are given in Tables 1, 2 and 3. The land use classifications used in this report are forest, pasture, hayfield, conventional tillage crop, minimum tillage crop, idle, low density residential ($\frac{1}{2}$ - 1 dwelling unit [DU] per acre), low/medium density (2 - 5 DU/acre), medium density (5 - 10 DU/acre), and high density (greater than 10 DU/acre). In these tables the numbers in parentheses are the percentages of subwatershed area for that particular land use.

Commercial areas are located primarily in subwatersheds 3 and 4. These are shopping centers or office buildings. There is no heavy industrial land use within the watershed. Agricultural land lies primarily in subwatersheds 1, 2 and 6. Comparison of 1974 with 1981 land use indicates an increase of commercial land by 25% and a decrease in conventional tillage land by 88%, largely due to changes in farming practice, from conventional to minimum tillage.

These land use maps are based on analysis of aerial photographs on file at Anne Arundel County Office of Planning and Zoning for 1970, 1977, and 1980. Using County maps for 1970 and 1977, changes within this time period were noted. Dates of development were determined through tax maps, development files in the Office of Planning and Zoning, and through interviews with long-time residents. This process provided the necessary information to create a land use map for 1974 at a scale of 1:4800.

| <u>SW</u> | <u>Forest</u> | <u>Pasture</u> | <u>Hayfield</u> | <u>Conventional Crop</u> | <u>Minimum Tillage</u> | <u>Idle</u> |
|-----------|------------------|----------------|------------------|------------------------------|----------------------------|-------------|
| 1 | 75.1*(38.5)** | 11. (5.6) | 14.8 (7.6) | 43.8 (22.5) | - | 13.8 (7.1) |
| 2 | 73.1 (40.2) | - | 14.8 (8.1) | 31.1 (17.1) | - | 5.2 (2.9) |
| 3 | 152.2 (39.1) | 9.2(2.4) | 17.8 (4.6) | - | - | 46.3 (11.9) |
| 4 | 48.0 (29.9) | 1.7 (1.0) | 12.5 (7.8) | 4.0 (2.5) | | 7.4 (4.6) |
| 5 | 71.2 (37.8) | 6.6 (3.5) | 10.5 (5.6) | 10.2 (5.4) | | 45.4 (24.1) |
| 6 | <u>1.8 (2.2)</u> | <u>-</u> | <u>5.9 (7.4)</u> | <u>11.2 (14.0)</u> | <u>-</u> | <u>-</u> |
| TOTAL | 421.4 (35.3) | 28.5 (2.4) | 76.3 (6.4) | 100.3 (8.4) | - | 118.1 (9.9) |

| | Low | Low/ Medium | Medium | High | | |
|-------|----------------------------|----------------|------------|-------------|-------------------|-------------------|
| | <u>Residential Density</u> | | | | <u>Commercial</u> | <u>TOTAL</u> |
| 1 | 34.4 (17.6) | 2.2 (1.1) | - | - | - | 195.1 (16.3) |
| 2 | 40.5 (22.2) | 11.7 (6.4) | - | - | 5.5 (3.0) | 181.9 (15.2) |
| 3 | 11.6 (3.0) | 31.3 (8.0) | 7.8 (2.0) | 1.4 (.4) | 111.4 (28.6) | 389.0 (32.5) |
| 4 | 11.7 (7.3) | 22.2 (13.8) | 36.7(22.8) | 14.2 (8.8) | 2.2 (1.4) | 160.6 (13.4) |
| 5 | 5.8 (3.1) | 9.4 (5.0) | - | 28.9 (15.4) | - | 188.0 (15.7) |
| 6 | <u>61.1 (76.4)</u> | <u>-</u> | <u>-</u> | <u>-</u> | <u>-</u> | <u>80.0 (6.7)</u> |
| TOTAL | 165.1 (13.8) | 76.8 (6.4) | 44.5 (3.7) | 44.5 (3.7) | 119.1 (10.0) | 1195.0 |

* Acres

** Percentage

Table 1 1974 LAND USE

| <u>SW</u> | <u>Forest</u> | <u>Pasture</u> | <u>Hayfield</u> | <u>Conventional Crop</u> | <u>Minimum Tillage</u> | <u>Idle</u> |
|-----------|--------------------|------------------|--------------------|------------------------------|----------------------------|-------------|
| 1 | 81.7*(40.6)** | 16.8 (8.3) | 2.6 (1.3) | 5.9 (2.9) | 21.3 (10.6) | - |
| 2 | 74.4 (38.2) | .9 (.5) | 3.8 (1.9) | 2.3 (1.2) | 30.9 (15.8) | 14.3 (7.3) |
| 3 | 147.9 (38.5) | - | 18.1 (4.7) | 1.3 (.3) | - | 30.0 (7.8) |
| 4 | 54.5 (34.3) | 11.3 (7.1) | - | 3.6 (2.3) | - | - |
| 5 | 84.6 (44.2) | 2.9 (1.5) | 9.6 (5.0) | 8.8 (4.6) | - | 40.4 (21.1) |
| 6 | <u>14.2 (18.2)</u> | <u>2.6 (3.3)</u> | <u>13.2 (16.9)</u> | <u>-</u> | <u>-</u> | <u>-</u> |
| TOTAL | 457.3 (37.8) | 34.5 (2.8) | 47.3 (3.9) | 21.9 (1.8) | 52.2 (4.3) | 84.7 (7.0) |

| | <u>Low</u> | <u>Low/ Medium</u> | <u>Medium</u> | <u>High</u> | <u>Commercial</u> | <u>TOTAL</u> |
|-------|----------------------------|------------------------|---------------|-------------|-------------------|-------------------|
| | <u>Residential Density</u> | | | | | |
| 1 | 72.9 (36.2) | - | - | - | - | 201.2 (16.6) |
| 2 | 48.2 (24.8) | 8.0 (4.1) | - | - | 11.8 (6.1) | 194.6 (16.1) |
| 3 | 4.9 (1.3) | 41.3 (10.7) | 1.5 (.4) | 5.7 (1.5) | 133.7 (34.8) | 384.4 (31.8) |
| 4 | 1.6 (1.0) | 37.8 (23.7) | 30.6 (19.2) | 16.1 (10.1) | 3.6 (2.3) | 159.1 (13.1) |
| 5 | 2.8 (1.5) | 9.6 (5.0) | - | 32.6 (17.0) | - | 191.3 (15.8) |
| 6 | <u>47.9 (61.5)</u> | <u>-</u> | <u>-</u> | <u>-</u> | <u>-</u> | <u>77.9 (6.4)</u> |
| TOTAL | 178.3 (14.7) | 96.7 (8.0) | 32.1 (2.6) | 54.4 (4.5) | 149.1 (12.3) | 1209.0 |

* Acres

** Percentage

Table 2 1981 LAND USE

| | Low | Low/ Medium | Medium | High | | |
|-------|----------------------------|----------------|-------------------|-------------|-------------------|-------------------|
| | <u>Residential Density</u> | | | | <u>Commercial</u> | <u>TOTAL</u> |
| 1 | 73.3*(36.2)** | 129.4 (63.8) | - | - | - | 202.7 (16.5) |
| 2 | - | 126.2 (62.7) | 56.7 (28.2)*** | - | 18.5 (9.2) | 201.4 (16.4) |
| 3 | 14.5 (3.7) | 20.4 (5.2) | 35.2 (9.0) | 48.6(12.5) | 271.3(69.6) | 390.0 (31.8) |
| 4 | - | 46.8 (29.1) | 20.7 (12.8) | 93.5(58.1) | - | 161.0 (13.1) |
| 5 | - | 3.3 (1.7) | 96.9 (50.5) | 91.7(47.8) | - | 191.9 (15.6) |
| 6 | <u>72.0 (88.7)</u> | <u>-</u> | <u>9.2 (11.3)</u> | <u>-</u> | <u>-</u> | <u>81.2 (6.6)</u> |
| TOTAL | 159.8 (13.0) | 326.1 (26.6) | 218.7 (17.8) | 233.8(19.0) | 289.8(23.6) | 1228.0 |

* Acres

** Percentage

*** See comment on page 66

Table 3 GDP LAND USE

Land use maps for 1981, based on 1980 aerial photos, have been generated by the Office of Planning and Zoning for the Annapolis Neck Sector Plan. This information was further refined by field checking for types of farm practices as well as percent imperviousness of developed areas. New maps were drafted by us using the land use categories needed for input to the WATER SCREEN program.

Maps prepared for the Anne Arundel County General Development Plan were enlarged to 1:4800 scale to determine how this land use might affect the creek. The GDP provides policy direction; it does not show what will physically happen to the watershed. For the purpose of this study it was hypothesized that development would occur without normal regulatory controls and without regard to existing development.

Input Parameters for WATER SCREEN

Input parameters for the Church Creek watershed used in WATER SCREEN are listed in Table 4.

Soil maps indicate most of the watershed is composed of loamy sand, but in subwatershed 4 there is some fine sandy loam; the soil erodibility factor K was adjusted to account for this.²⁵

The length-slope factor (LS) was obtained from the 1:4800 contour maps by "eyeball" estimates of average lengths to a stream channel and typical changes in elevation. The difficulty in determining these average values is illustrated in Figure 6'.

For the irregularly shaped land use area shown in Figure 6'(a) it is not clear how to arrive at an average value of length because

| <u>Function</u> | <u>Parameter</u> | <u>Sub- Watershed</u> | <u>Land Use</u> | <u>Parameter Value</u> | <u>Source</u> |
|-----------------|------------------|---------------------------|-------------------------|----------------------------|-------------------|
| MUSLE | R | All | All | 200 | Reference 12 |
| | K | 1 | All | .43 | " " |
| | | 2 | " | .43 | |
| | | 3 | " | .43 | |
| | | 4 | " | .35 | |
| | | 5 | " | .43 | |
| | | 6 | " | .43 | |
| " | LS | See Table 5 | | | 1/4800 scale maps |
| | | | | | Reference 12 |
| " | C | All | Forest | .003 | Reference 16 |
| | | | Pasture | .013 | |
| | | | Hayfield | .009 | |
| | | | Idle | .012 | |
| | | | Conventional Crop | .319 | |
| | | | Minimum Tillage Crop | .185 | |
| " | P | All | Non-cropland | 1.0 | Reference 16 |
| | | | Cropland | .75 | |
| " | S _D | 1 | All | .5 | 1/4800 scale maps |
| | | 2 | " | .54 | Reference 12 |
| | | 3 | " | .48 | |
| | | 4 | " | .54 | |
| | | 5 | " | .54 | |
| | | 6 | " | .56 | |

TABLE 4 PARAMETER VALUES FOR CHURCH CREEK WATERSHED

| <u>Year</u> | <u>Sub- Watershed</u> | <u>Forest</u> | <u>Pasture</u> | <u>Hayfield</u> | <u>Conventional Crop</u> | <u>Minimum Tillage</u> | <u>Idle</u> |
|-------------|---------------------------|---------------|----------------|-----------------|------------------------------|----------------------------|-------------|
| 1974 | 1 | 1.2 | .45 | .53 | .55 | - | .25 |
| | 2 | .45 | - | .55 | .35 | - | .38 |
| | 3 | .33 | .3 | .26 | - | - | .26 |
| | 4 | 1.1 | 1.0 | .28 | .7 | - | .33 |
| | 5 | 1.7 | .9 | .75 | .4 | - | .28 |
| | 6 | 1.0 | - | 1.2 | .8 | - | - |
| 1981 | 1 | 2.5 | .15 | .4 | 1.1 | 2.0 | - |
| | 2 | .5 | .4 | .75 | .3 | 1.4 | .31 |
| | 3 | .6 | - | .55 | .4 | - | .4 |
| | 4 | 1.9 | .8 | 1.6 | .7 | - | - |
| | 5 | 1.3 | .4 | .9 | .4 | - | .3 |
| | 6 | 3.0 | 1.3 | 1.7 | - | - | - |

TABLE 5 LS PARAMETER VALUES FOR CHURCH CREEK WATERSHED

of the greater distance the soil must travel from the upper branch of this land use area as compared to soil eroded in the lower branch. In addition, part of this field may have a variation in elevation as shown in Figure 6'(b). Furthermore, there may be more than one location having the same land use within a particular subwatershed, as illustrated in Figure 6'(c).

An attempt was made to deal with these averaging problems by choosing a location that appeared to represent an average distance to stream channel and average elevation for each land use. In the case of multiple areas within a given subwatershed with the same land use, an "average" of the "averages" was used.

It is recognized that this is not a satisfactory procedure. First of all, it depends upon individual choices and therefore is not reproducible. Even for the same individual the subjective nature of the process can result in large uncertainties. For example, the values for the LS factor shown in Table 5 were done a week apart for 1974 and 1981 land use. Inspection of this table indicates that the LS factors for land use having little change between the two years may vary as much as a factor of two in the tabulated values. Secondly, it is not clear what an appropriate weighting procedure should be when the average value of the LS factor for separate land use areas of variable size, elevation, and distance from stream channel is desired.

The question of the proper averaging procedure for a collection of differing or spatially separated fields is a fundamental problem in the MUSLE approach.¹⁸ The original USLE was meant to be applied to a single field. It is likely that a reproducible averaging procedure could be

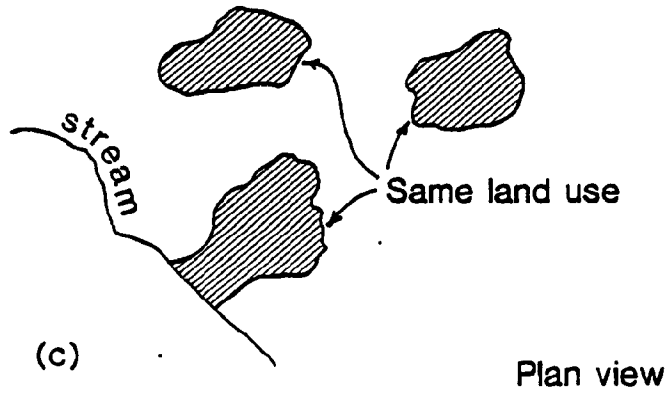
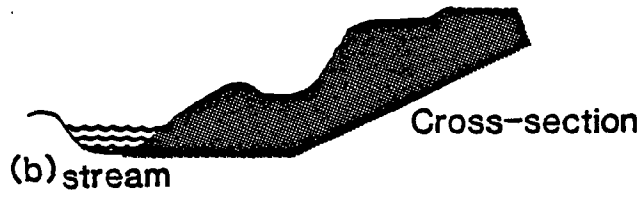
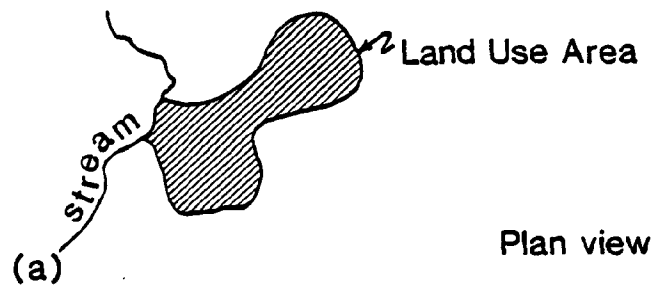


Figure 6'. Problems in estimating average (LS) factor.

developed based on superimposing a square grid on the watershed contour map and assigning values for the various factors based on well defined procedures. A weighting scheme could be used in conjunction with the grid values to arrive at average values.^{2, 26-31} Questions then arise as to the minimum grid size necessary, and as to the relative merits of different weighting schemes. Answers to these questions will require further studies of single and multiple use watersheds.

The values chosen for the cover factor C were based on assumptions as to the degree of canopy cover and ground cover. The cover factor for forest requires an estimate of the amount and type of forest litter. Values of C for conventional crop and minimum tillage crop assume a two year crop rotation as follows: first year corn, second year soybeans.

The agricultural practices factor has a value of 1.0 if no special practices are assumed. A value of .75 for cropland assumes that planting was done across the slope.

Sediment delivery ratio (S_D) values were found using a graph of S_D versus the reciprocal of the drainage density (Figure III-10, Zison et al.)¹² Drainage density is defined as the ratio of total channel-segment lengths to the watershed area. The reciprocal of the drainage density approximates the average distance a soil particle would have to travel from the point of erosion to the stream channel.

Loading factors in reference 9 are tabulated on the basis of soil type and percent imperviousness of the land surface. The values listed in Table 6 selected for Church Creek are for sandy loam soils and an average value for the range of percent imperviousness that is listed.

| <u>Pollutant</u> | <u>Land Use</u> | | | | | |
|------------------|-----------------|----------------|-----------------|--------------------------|------------------------|-------------|
| | <u>Forest</u> | <u>Pasture</u> | <u>Hayfield</u> | <u>Conventional Crop</u> | <u>Minimum Tillage</u> | <u>Idle</u> |
| Sediment | 20 | 20 | 20 | 1580 | 900 | 20 |
| Nitrogen | 2.4 | 4.3 | 2.6 | 12.5 | 8.7 | 2.6 |
| Phosphorous | .1 | .3 | .1 | 2.3 | 1.1 | .1 |
| BOD | 6 | 13 | 6 | 29 | 19 | 6 |
| Lead | .01 | .01 | .01 | .02 | .02 | .01 |
| Zinc | .01 | .02 | .01 | .1 | .1 | .01 |

| <u>Pollutant</u> | <u>Land Use</u> | | | | |
|------------------|--------------------|---------------------------|-----------------------|---------------------|-------------------|
| | <u>Low Density</u> | <u>Low/Medium Density</u> | <u>Medium Density</u> | <u>High Density</u> | <u>Commercial</u> |
| Sediment | 120 | 240 | 420 | 560 | 480 |
| Nitrogen | 5.1 | 7.1 | 9.7 | 12.5 | 13.2 |
| Phosphorous | .5 | .8 | 1.1 | 1.7 | 1.6 |
| BOD | 13 | 18 | 25 | 36 | 163 |
| Lead | .12 | .29 | .59 | .97 | 2.58 |
| Zinc | .11 | .23 | .38 | .55 | 2.06 |

TABLE 6 LOADING FACTORS (LBS/ACRE/YEAR) SELECTED FOR CHURCH CREEK WATERSHED⁹

Some of the loading factors listed in Table 6 have been revised based on recent recalibration measurements.¹¹ The effect of these revisions on our estimates for the Church Creek watershed will be discussed in a later section.

Comparison of MUSLE method with Loading Factor Approach

Loading estimates from both the MUSLE and loading factor methods are shown for sediment, total nitrogen, and total phosphorous in Figures 7, 8 and 9, respectively. These results are only for forest and agricultural land use within the watershed. As can be seen, the MUSLE method estimates a much larger amount of sediment, by a factor of 10 to 20, than that estimated from the loading factor method. However, estimates for total nitrogen and total phosphorous are just the opposite; the MUSLE estimates are a factor of 4 to 15 times lower than those given by the loading factor approach. Only in the case of minimum tillage crop are the estimates of comparable size. Both the nitrogen and phosphorous loading functions used with the MUSLE approach relate the amount of nutrient to the amount of sediment; therefore one would expect the sediment, nitrogen, and phosphorous estimates to all be high or low, but they are not.

Possible reasons for the discrepancy between the two methods are:

1. Nitrogen and phosphorous loading functions that were used are not correct or not appropriate for this watershed.
2. The loading factors used are not appropriate for this watershed.

The transport of nitrogen and phosphorous have been intensively studied because of their importance in the eutrophication of natural

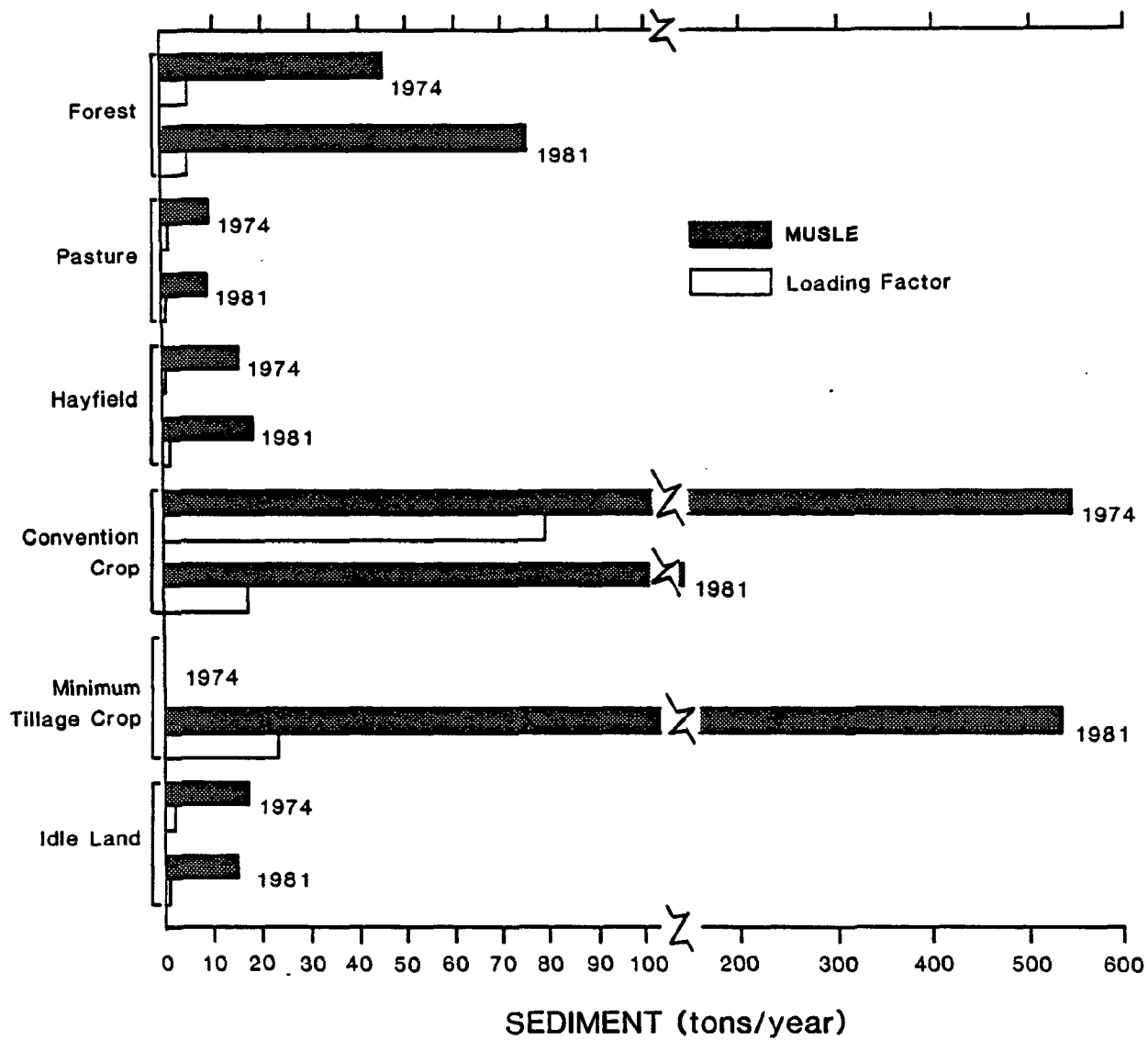


Figure 7.
Comparison of MUSLE and
loading factor estimates—sediment

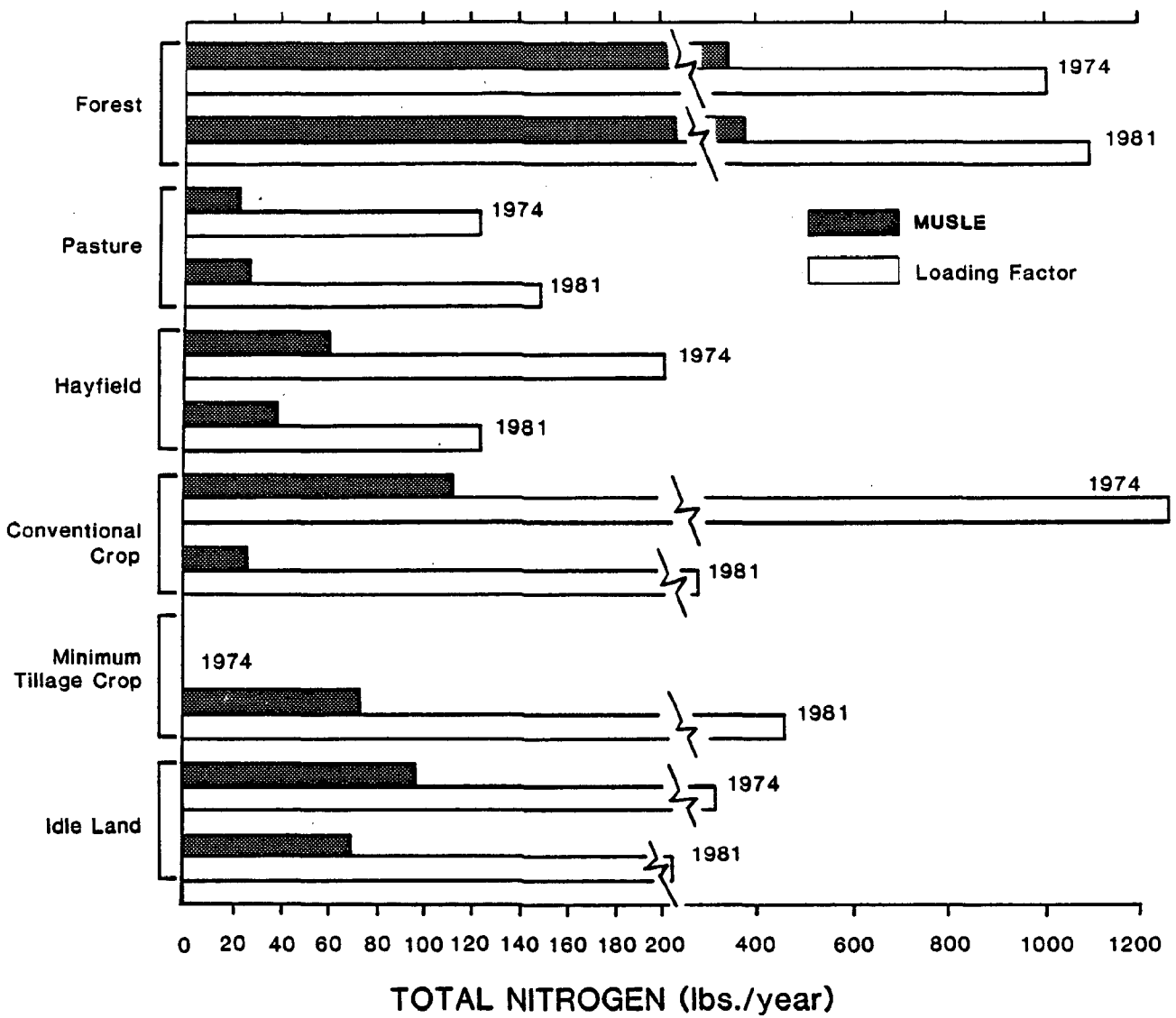


Figure 8 .

Comparison of MUSLE and loading factor estimates -Total nitrogen

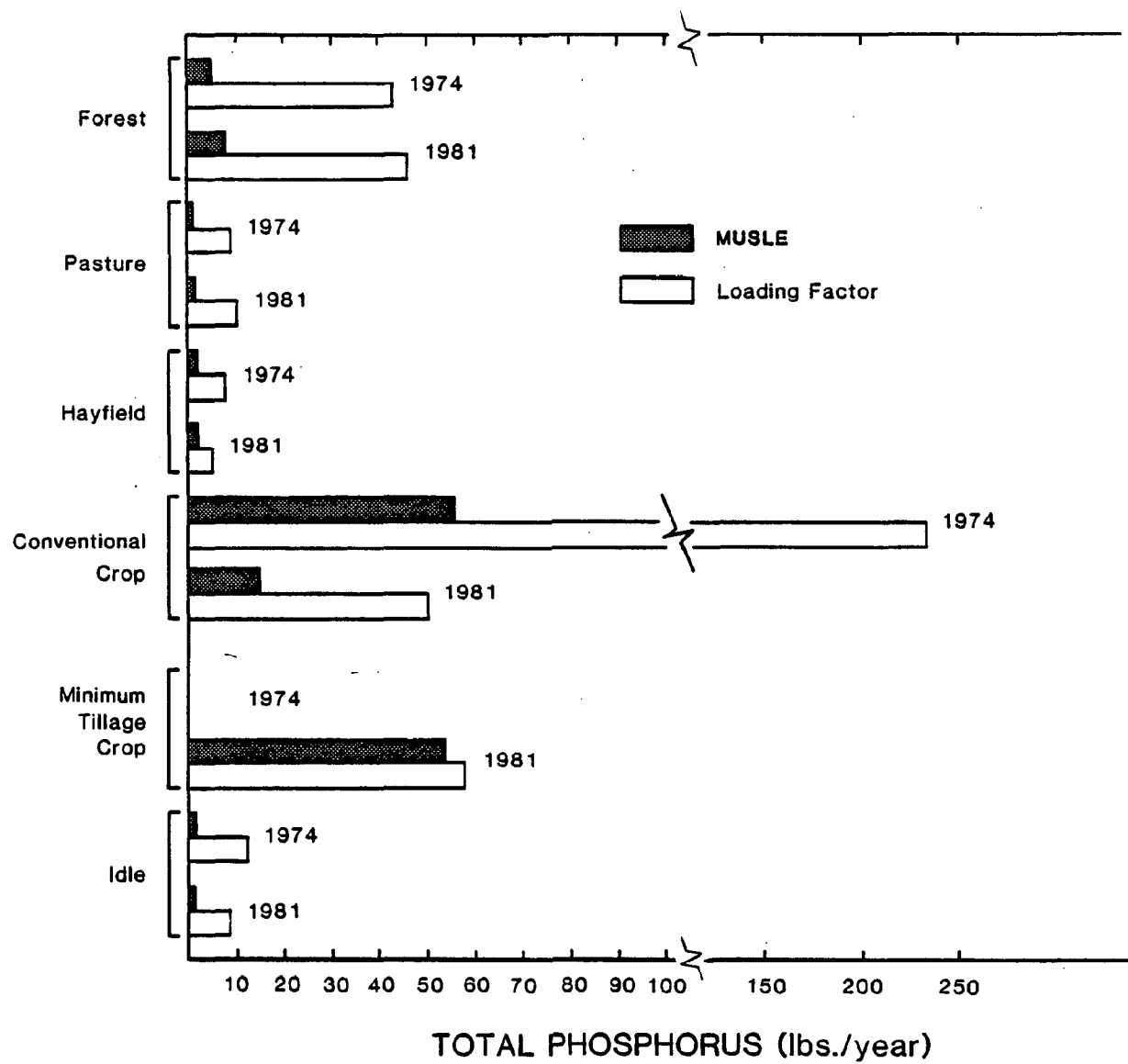


Figure 9.
Comparison of MUSLE and loading
factor estimates—Total phosphorus

waters.^{19,32,33} They are part of an extremely complex process with some of the details still not well understood. It is therefore not unlikely that the simplified method of estimating nitrogen and phosphorous loadings by means of loading functions is not correct.

Recent work in the Chesapeake Bay Program found that the loading factors developed for the Occoquan River basin in Northern Virginia were comparable to values found in small watersheds located in the Pequea Creek region near Lancaster, Pennsylvania.²⁴ Work with other watersheds within the Chesapeake Bay watershed also indicated comparable loading factors. This suggests that these loading factors are appropriate for use with the Church Creek watershed provided there are no unique characteristics of the Church Creek watershed which distinguish it from the watersheds on which the loading factors are based.

The Smithsonian Institution's Chesapeake Bay Center for Environmental Studies is located on the Rhode River, which is the nearest sub-estuary of the Chesapeake Bay south of the South River. (See Figure 1.) Center workers have carried out an extensive study of the Rhode River watershed. Some of the measured values they obtained for nitrogen, phosphorous, and sediment loading factors are given in Table 7. Comparing their measured values with those chosen for the Church Creek watershed (Table 6), the nitrogen and phosphorous values for forest are in reasonable agreement; for pasture/hayfield they disagree by a factor of 3 to 15; and for cultivated land they differ by factors of 2 to 4. It is more difficult to compare the sediment loading result because of the mixed land use within the Rhode River subwatersheds. Basins 101, 103 and 105 have similar land use patterns, so that the values ranging from

| <u>Land Use</u> | <u>Nitrogen</u> | <u>Phosphorous</u> |
|-----------------|-----------------|--------------------|
| Cultivated | 3.3* | 1.2* |
| Pasture/Hay | 11.6 | 3.4 |
| Forest | 1.3 | .18 |

| <u>Basin</u> | | <u>1974</u> | <u>1975</u> | <u>1976</u> |
|--------------|---------------------------------------|-------------|-------------|-------------|
| 101 | Forest, old fields, pasture | 67* | 456 | 286 |
| 102 | Forest, pasture, row crops | 40 | 136 | 113 |
| 103 | Forest, old fields, pasture | | | 220 |
| 105 | Forest, old fields, pasture | | 254 | 178 |
| 108 | Forest, pasture, row crops, hayfields | 71 | 426 | 327 |

*(lbs/acre/year)

TABLE 7 MEASURED LOADINGS FROM RHODE RIVER SUBWATERSHEDS.^{34,35}

67 to 456 lbs/acre/year should be comparable to the loading factor listed in Table 6 of 20 lbs/acre/year, but they are not. The lower measured value was obtained in a year having less rainfall, so that part of the difference may be reduced if measured values for several years were to be averaged.

A recent study of five small subwatersheds in the Patuxent River Basin arrived at average measured loading factors.²³ For forest they found an average loading factor for total suspended solids of 141 lbs/acre/year with a standard error of 89 lbs/acre/year and a range of measured values from 6 to 2074 lbs/acre/year. These results along with the variation in sediment discharge from year to year (shown in Table 7) provide good examples of the necessity for loading factors to be based on several years of measurements. The data collected by the VPI group on small watersheds in the Occoquan River Basin illustrates the possible range of measured values.²² For example, the range of measured values for total nitrogen from a forested area overlaps the range of measured values produced by minimum tillage-corn land use. Nevertheless, there is a significant difference between the median values for these two land uses.

As the previous discussion has indicated, selected loading factors for nearby watersheds differ from the Northern Virginia Planning District Commission (NVPDC) values to some extent. However, the variability of measured loading factors from year to year indicates that a statistical average of several years of data should be used to obtain a reasonable average value for loading factors. We therefore have selected the NVPDC loading factors (Table 6) as the best available values.

While writing this report we received the recently revised loading factors from NVPDC based on additional measurements.¹¹ There were no changes in the nitrogen, phosphorous, and BOD loading factors. A 33% reduction in the zinc loading factor for single family residential (0.5-6.0 DU/acre) and townhouse garden apartments (6.0-20.0 DU/acre) was recommended. For lead a 50% reduction was recommended for single family residential and a 33% reduction for townhouse garden apartments. Based on a better sampling technique for suspended solids they recommend a 33% reduction in the sediment loading factor for all residential land use categories.

Part of the reduction in the lead loading factor may be due to the increased use of no-lead gasoline so that the original lead loading factor may be more appropriate for the 1974 and 1981 land use patterns. In any case, the revised loading factors do not significantly affect the nutrient and pollutant loading estimates in this report which are based on the earlier loading factors from NVPDC.

Nutrient and Pollutant Discharge to Church Creek

The loading factor method was used to estimate nutrient and pollutant loadings for four different land use patterns:

1. The appropriate loading factor for forest land use was multiplied by the total land area (1200 acres) to give an estimate for each pollutant of the total loadings if the whole watershed were completely forested. This is called the "all forest" land use pattern and serves as an index of minimum loadings from the watershed.

2. 1974 land use.
3. 1981 land use.
4. Hypothesized development based on the current General Development Plan (GDP). This serves as an index of the maximum loading from the watershed.

Figures 10 through 15 show the loadings for sediment, total nitrogen, total phosphorous, biological oxygen demand (BOD), lead, and zinc for each of the eleven categories of land use. In general, no significant change in loadings between 1974 and 1981 was noted except in two categories. The change from conventional to minimum tillage practices on some of the farmland reduced the sediment, total nitrogen, and total phosphorous from this land use by a significant amount. On the other hand, increase in commercial land use increased BOD, lead, and zinc loadings by 25%.

Comparing the loadings for all four land use patterns indicates that high density residential and commercial land use can contribute significant loadings for all the pollutants studied. For example, in 1981 sediment from commercial land was almost as much as from cropland. One of the more surprising results is the large amount of BOD loading produced by commercial land. In 1981 the BOD loading from commercial land use in the watershed was a factor of three larger than would have been produced if all the land were still forested, even though commercial land in 1981 made up only 12% of the entire watershed. Loadings of zinc and lead are also disproportionally higher for commercial land as compared to other land uses within the watershed.

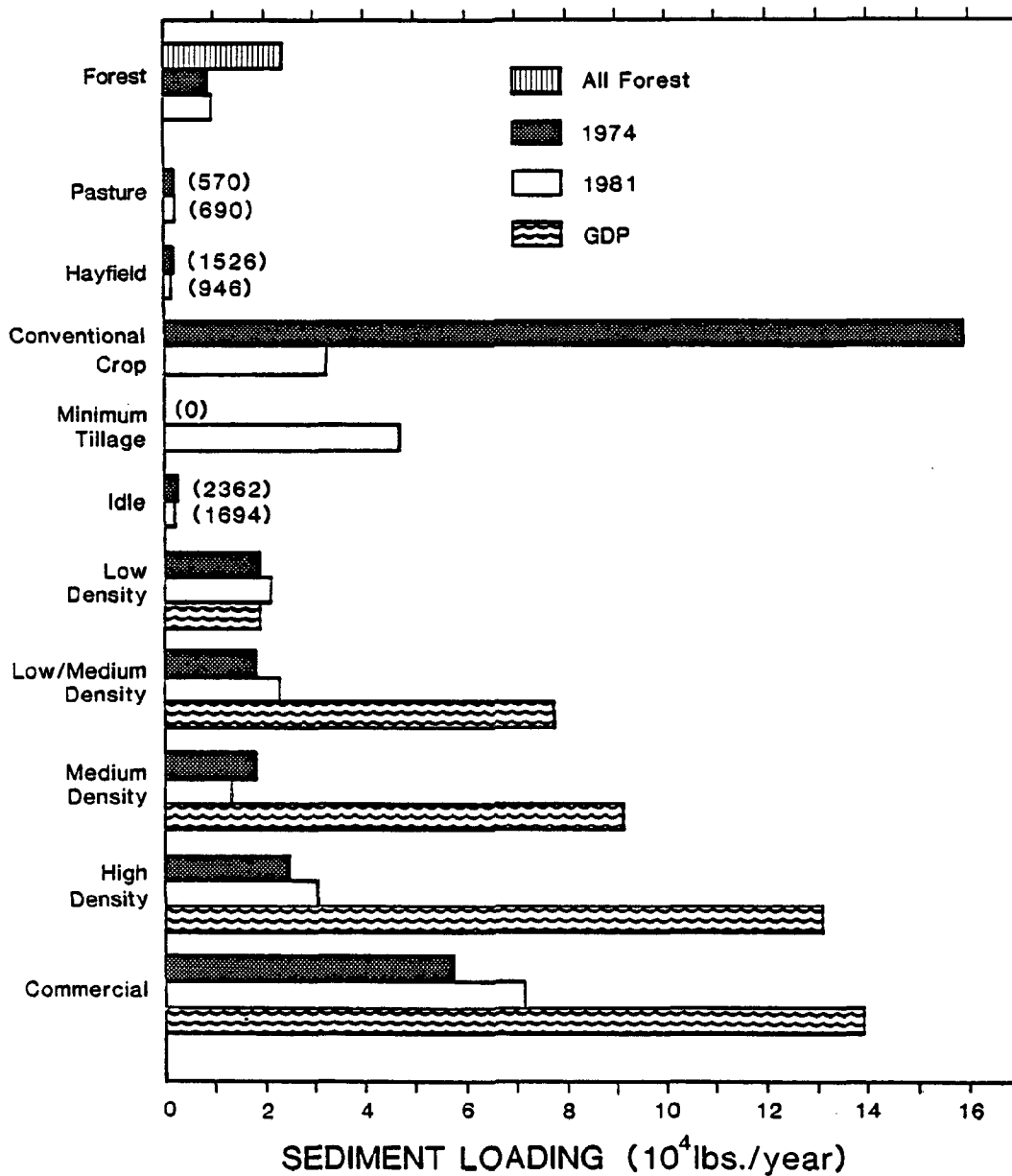


Figure 10.
Total Sediment Loading by Land Use

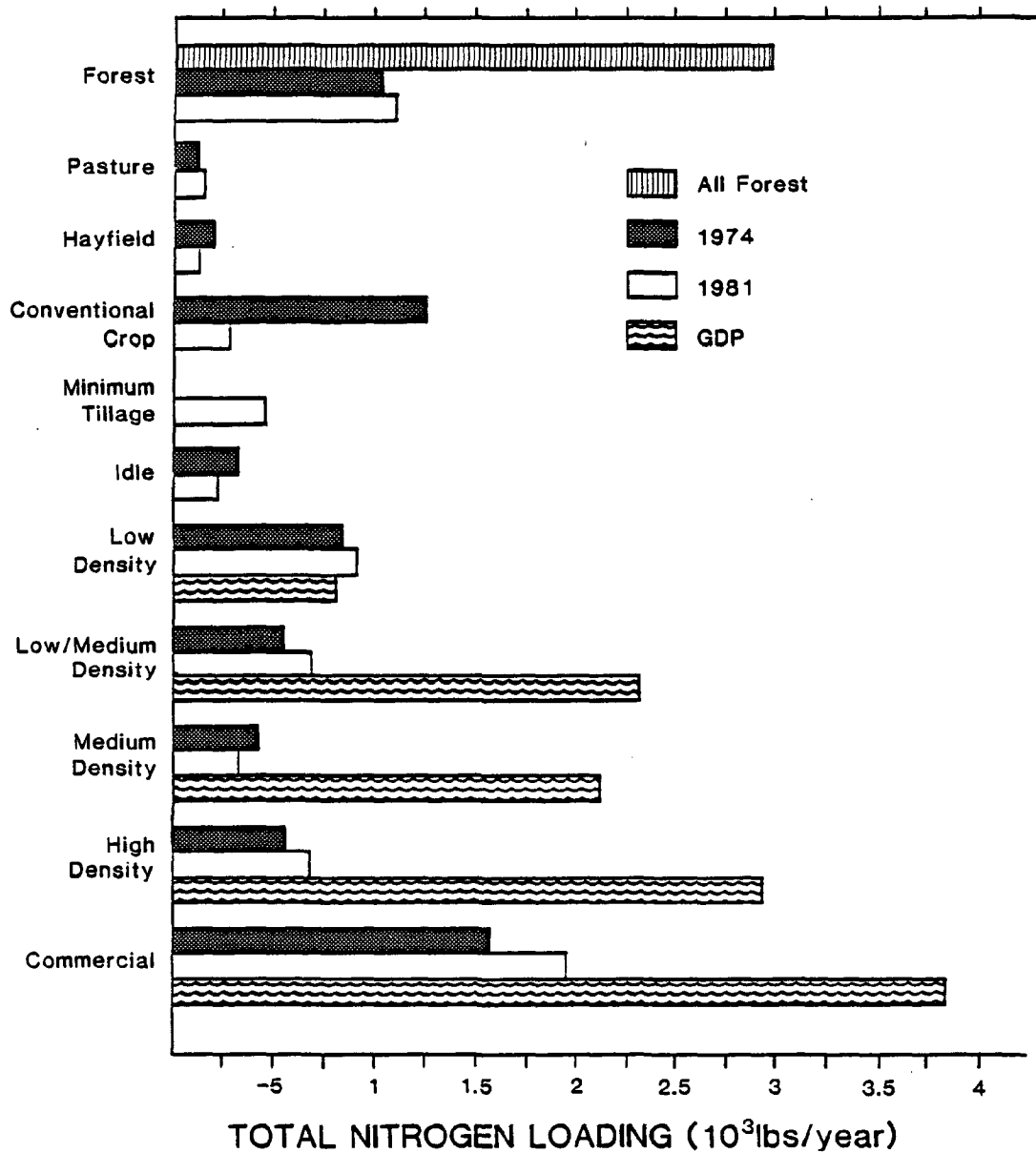


Figure 11.
Total Nitrogen Loading by Land Use

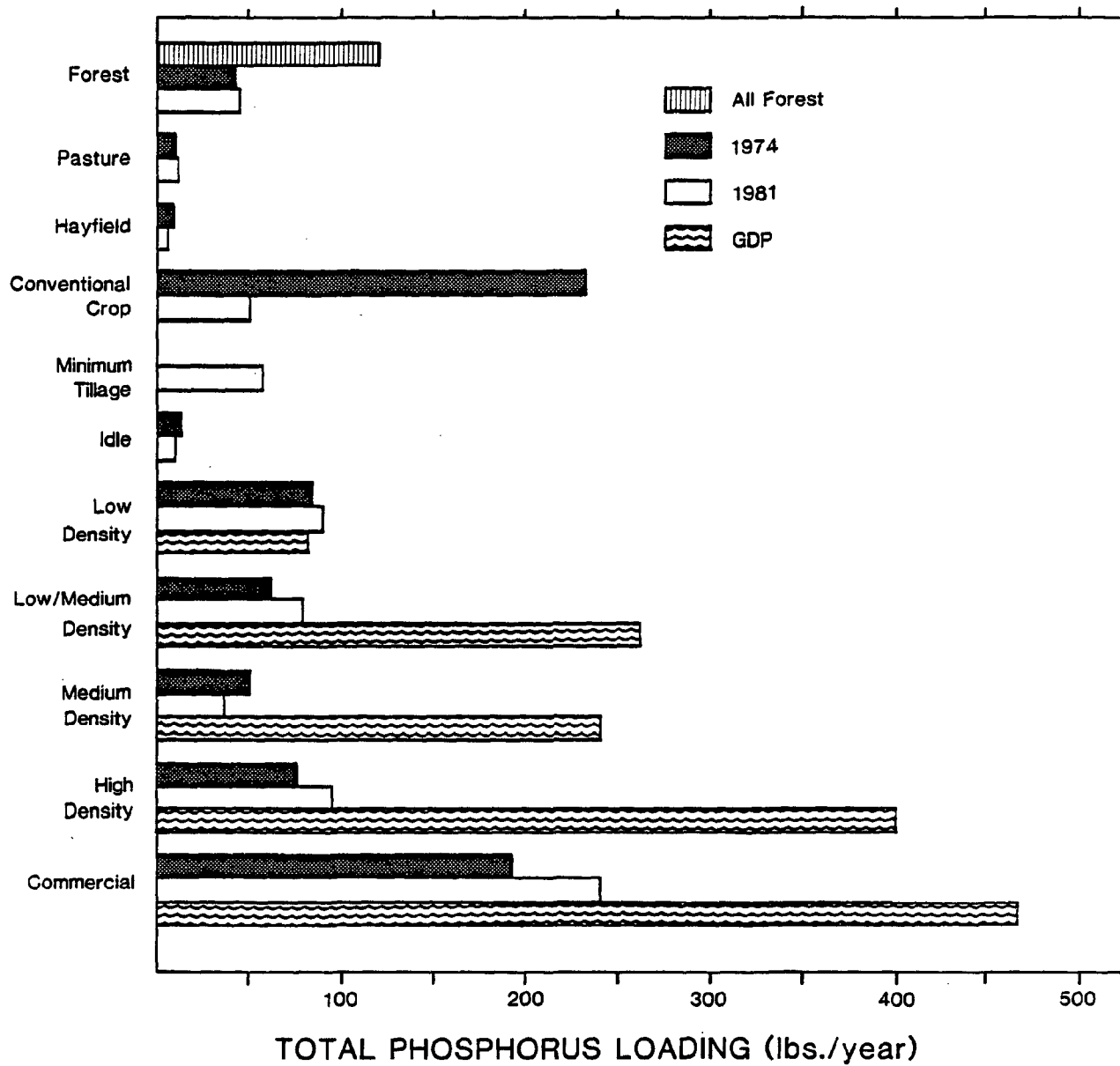


Figure 12
Total Phosphorous Loading by Land Use

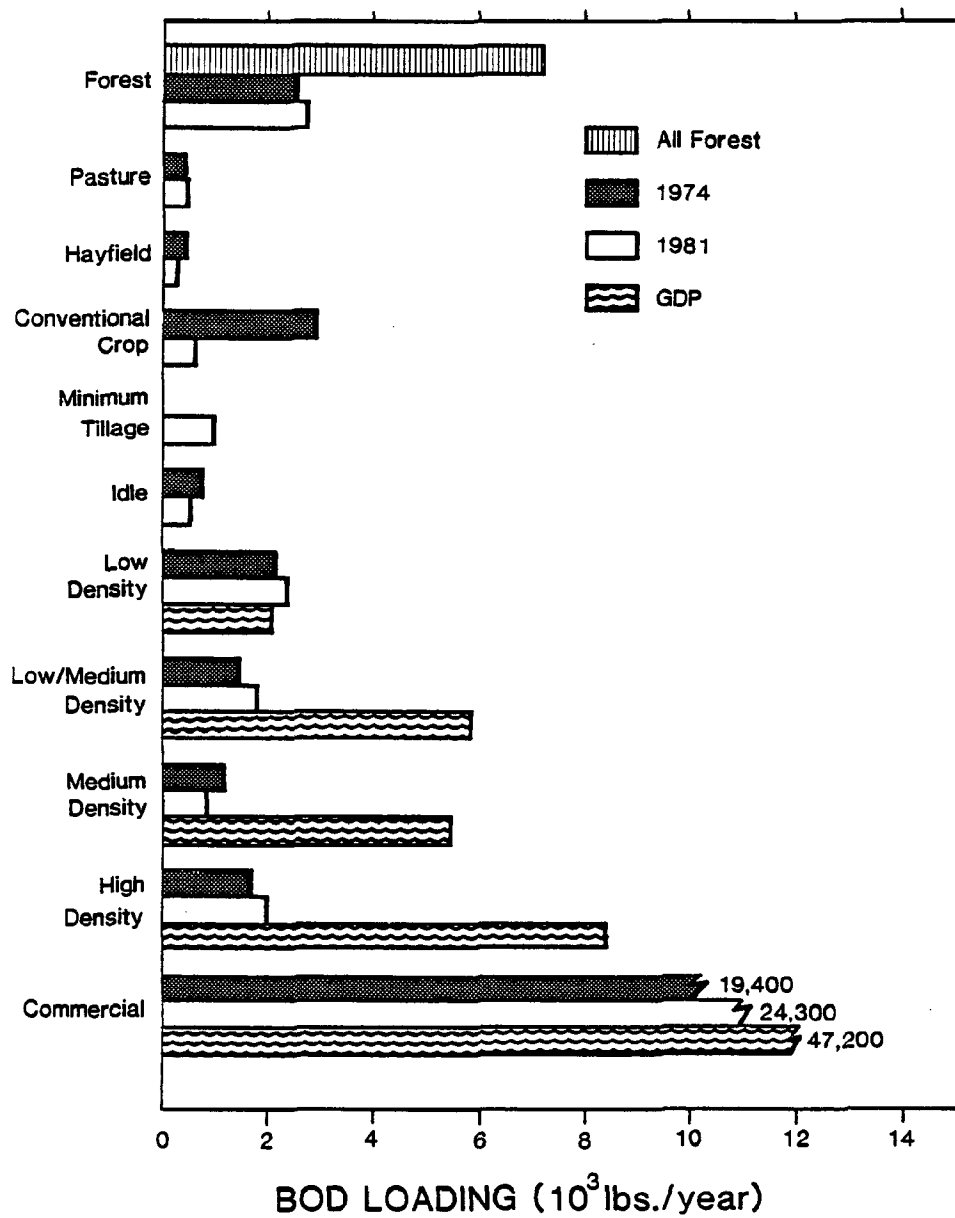


Figure 13.
BOD Loading by Land Use

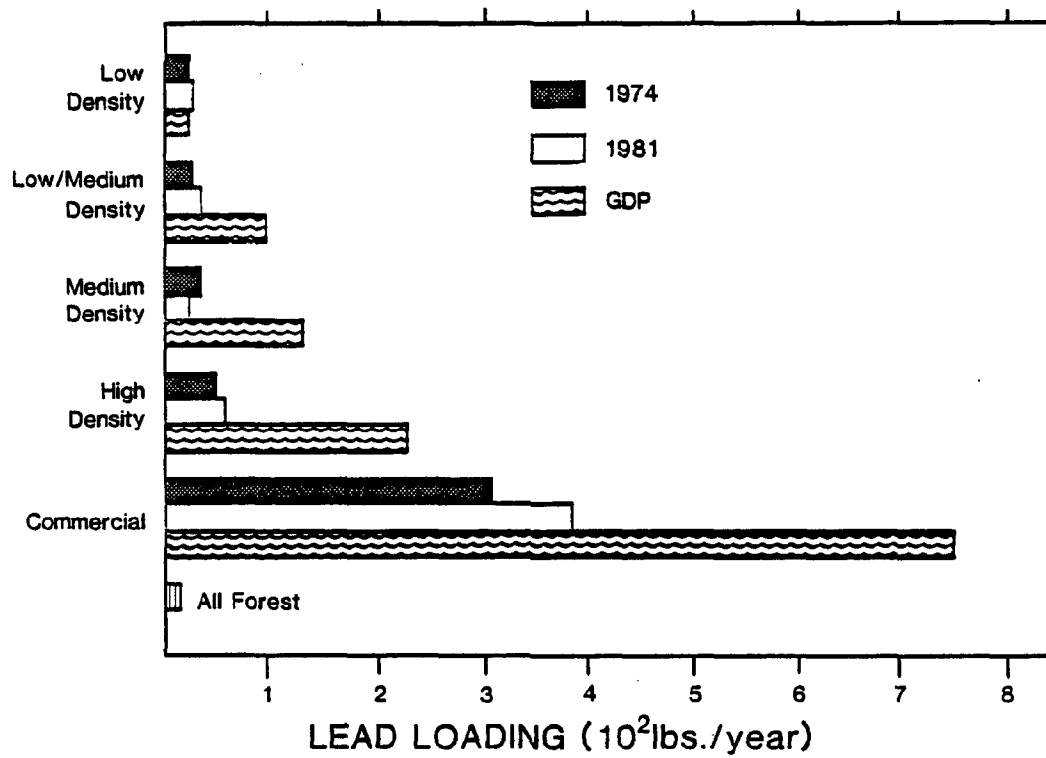


Figure 14.
Lead Loading by Land Use

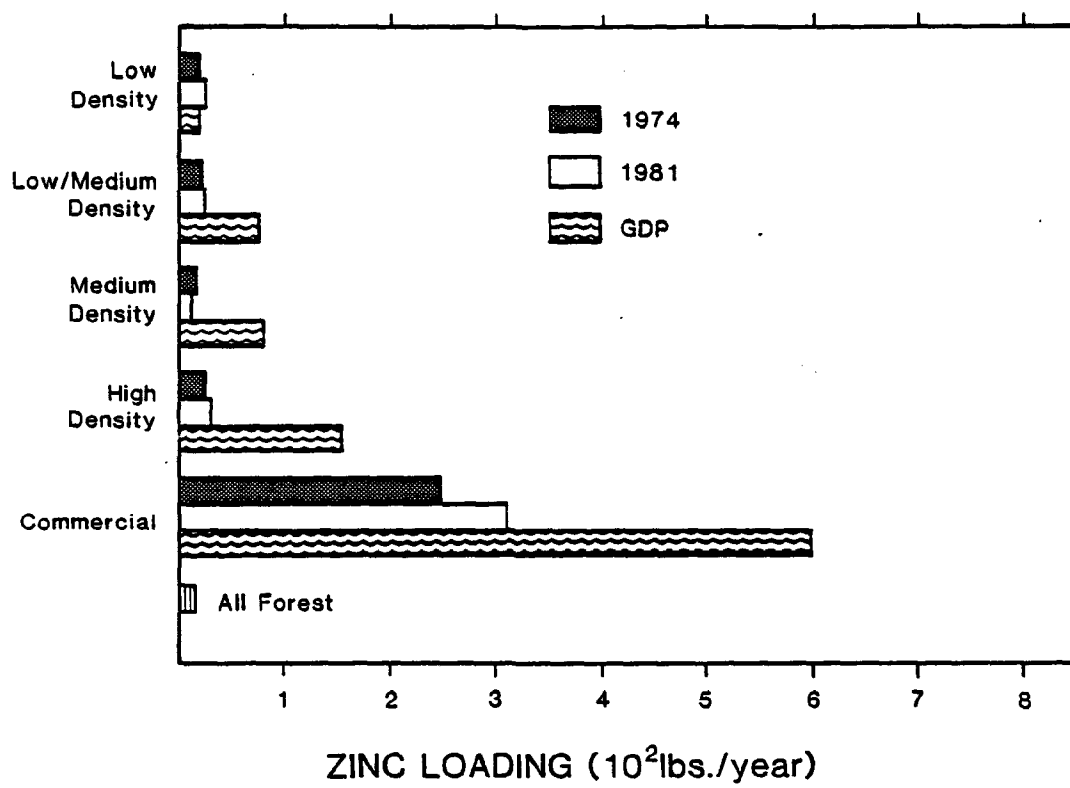


Figure 15.
Zinc Loading by Land Use

Figures 16 through 18 illustrate the estimated pollutant loadings by subwatershed. As can be seen, subwatershed 3 produces more of the loadings than the other subwatersheds. Some of this is accounted for by the larger area of subwatershed 3, but of more importance is the larger fraction of commercial land use in this watershed.

Figure 19 summarizes the estimated total pollutant loading by pollutant type for the four different development patterns considered. Between 1974 and 1981 there has been a small decrease in sediment and total phosphorous, total nitrogen has remained unchanged, and BOD, lead, and zinc have increased by about 25%. If one uses the "all forest" values for normalization, then by 1981 yearly sediment loading had increased by a factor of 10, total nitrogen by 2, total phosphorous by 7, BOD by 4.5, lead by 60, and zinc by 40. If the hypothetical land use patterns based on the GDP were to occur, then sediment would increase by a factor of 18, total nitrogen by 4, total phosphorous by 12, BOD by 9, lead by 100, and zinc by 75.

One source of lead that has not been accounted for in these estimates is the lead contained in stormwater runoff from the heavily traveled highways that are in the Church Creek watershed. A 1981 traffic survey found that the average daily traffic on Route 2, Forest Drive, West Street, and Riva Road was in the range from 14,000 to 32,000 vehicles/day.³⁶

A 1972 study of lead input into a watershed in Illinois assumes 2.5 g of lead per gallon of gasoline, and in urban areas 50% of the consumed lead is emitted from the exhaust system of the automobile.³⁷ For the Church Creek watershed we make the additional assumptions:

1. Within the watershed there are 5 miles of roads with an average traffic volume of 23,000 automobiles/day.

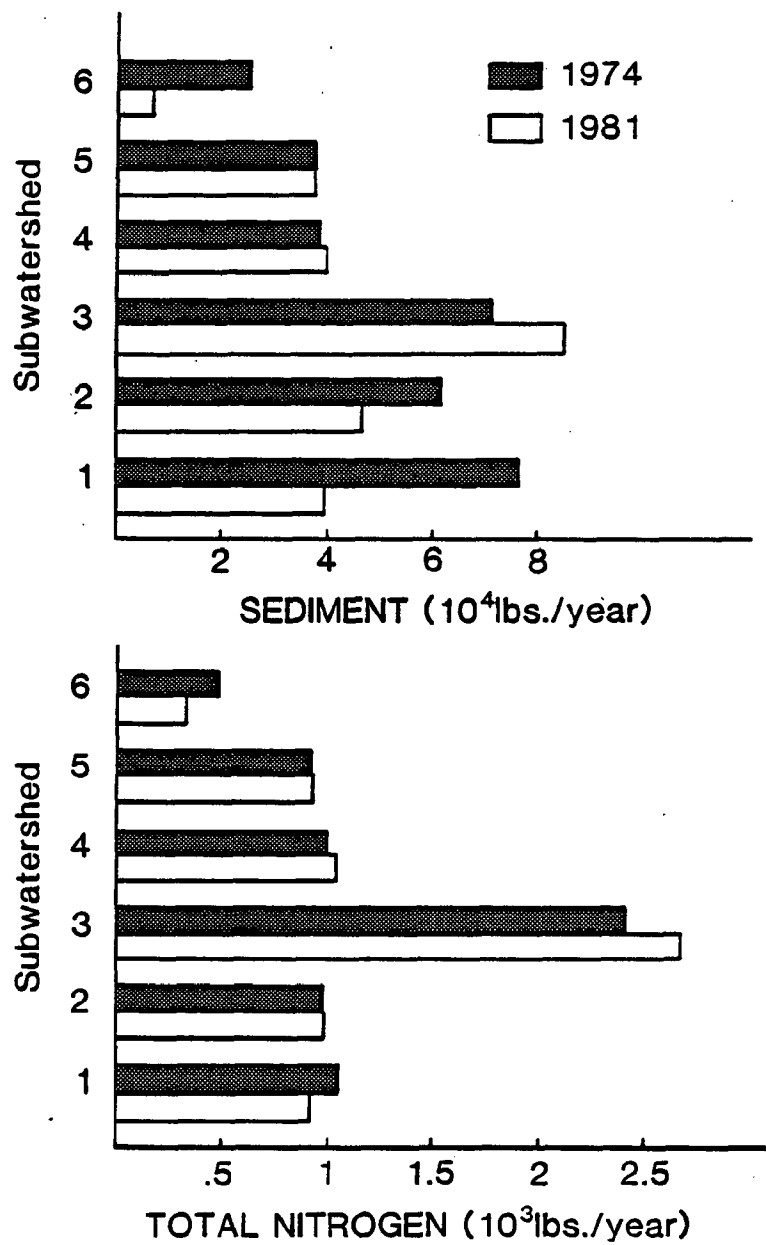


Figure 16.
Pollutant Loading by Subwatershed (Sediment and Nitrogen)

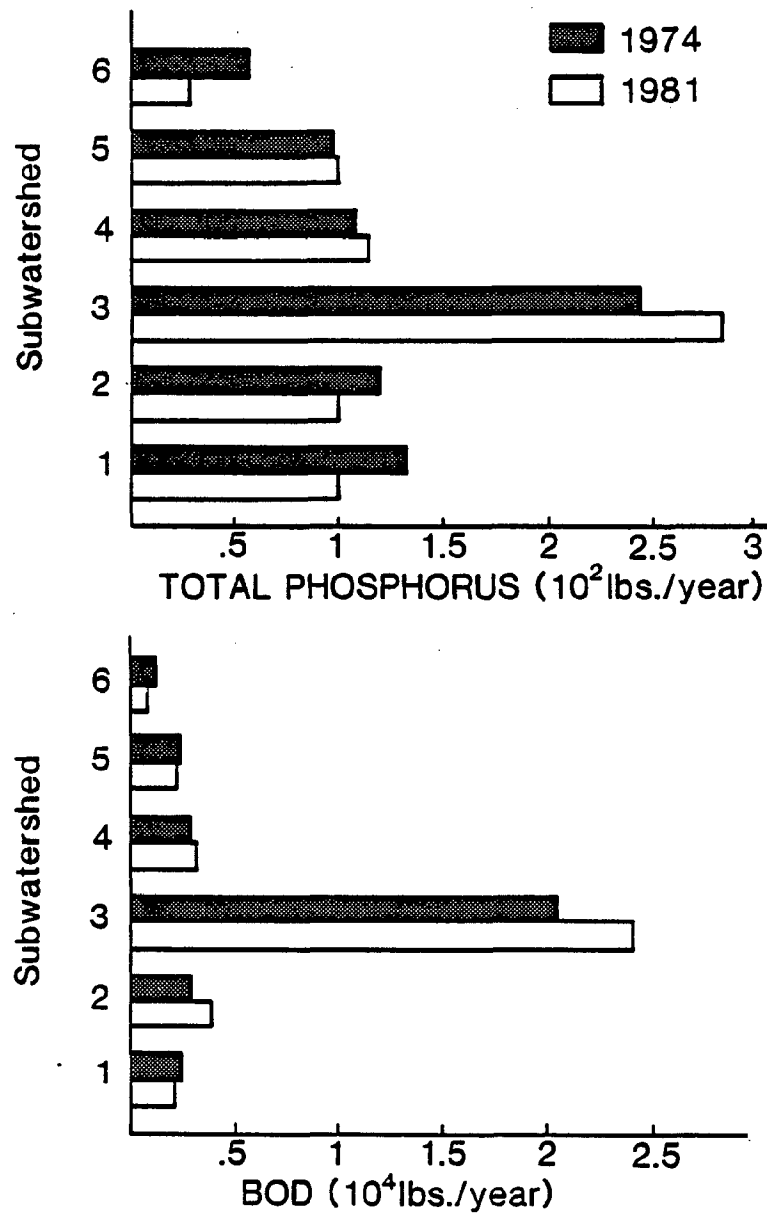


Figure 17.
Pollutant Loading by Subwatershed (Phosphorous and BOD)

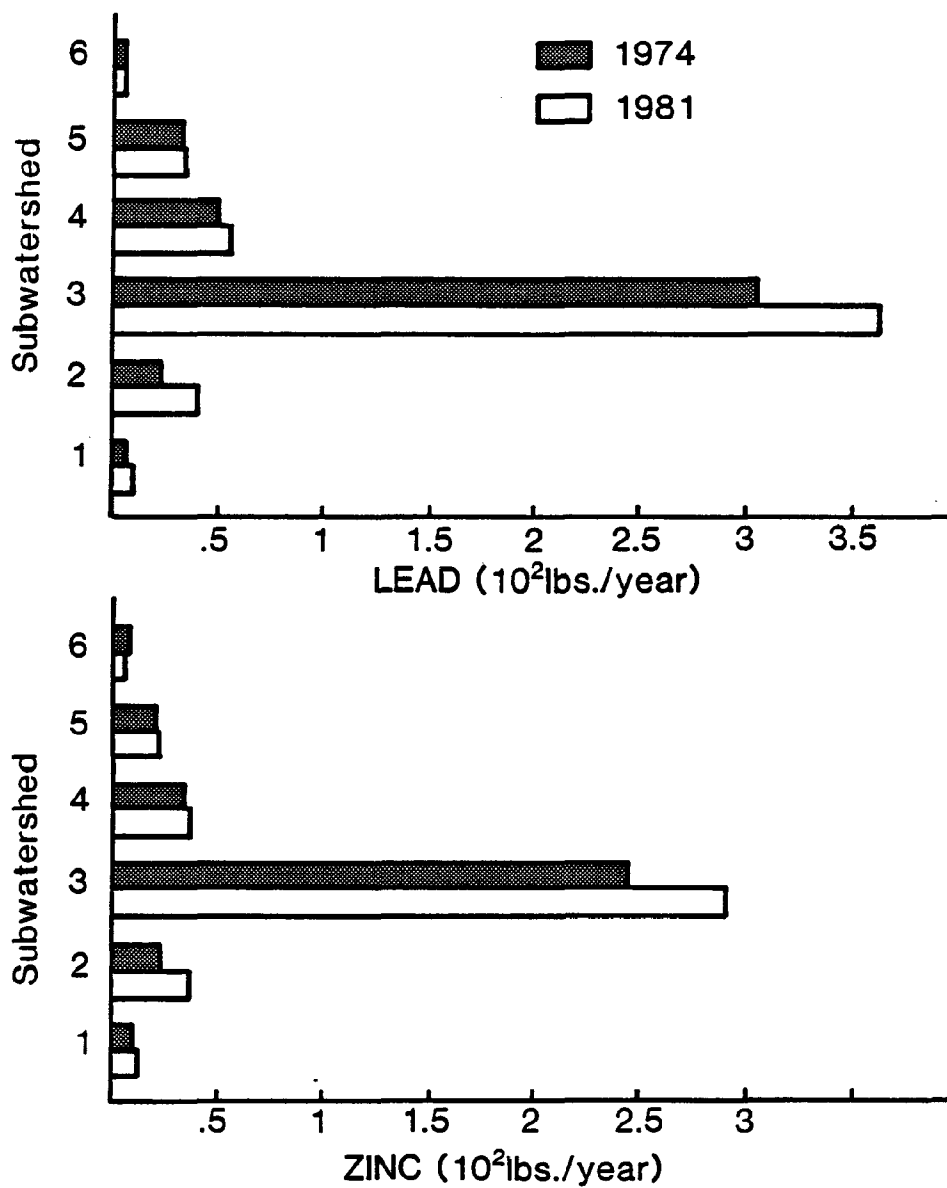


Figure 18.
Pollutant Loading by Subwatershed (Lead and Zinc)

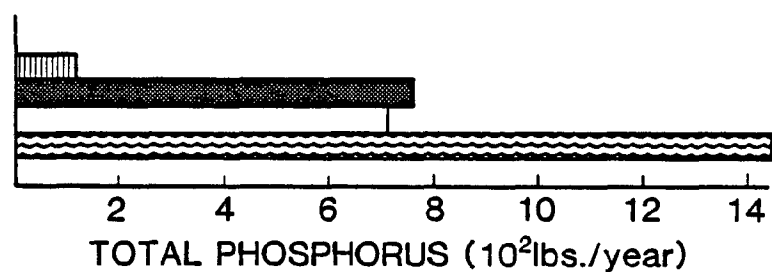
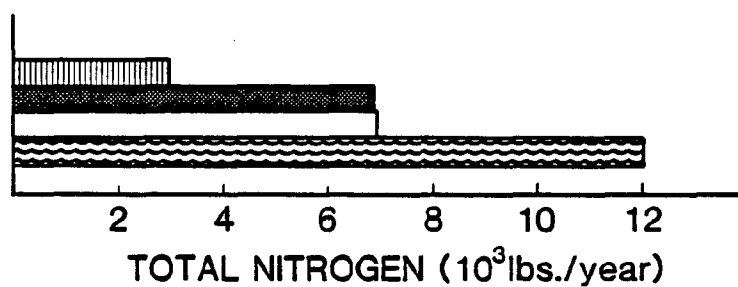
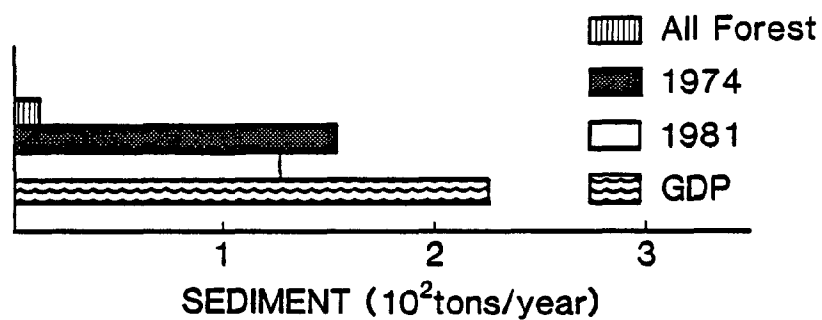


Figure 19.
Total Pollutant Loading from Church Creek
Watershed (Sediment, Nitrogen, Phosphorous)

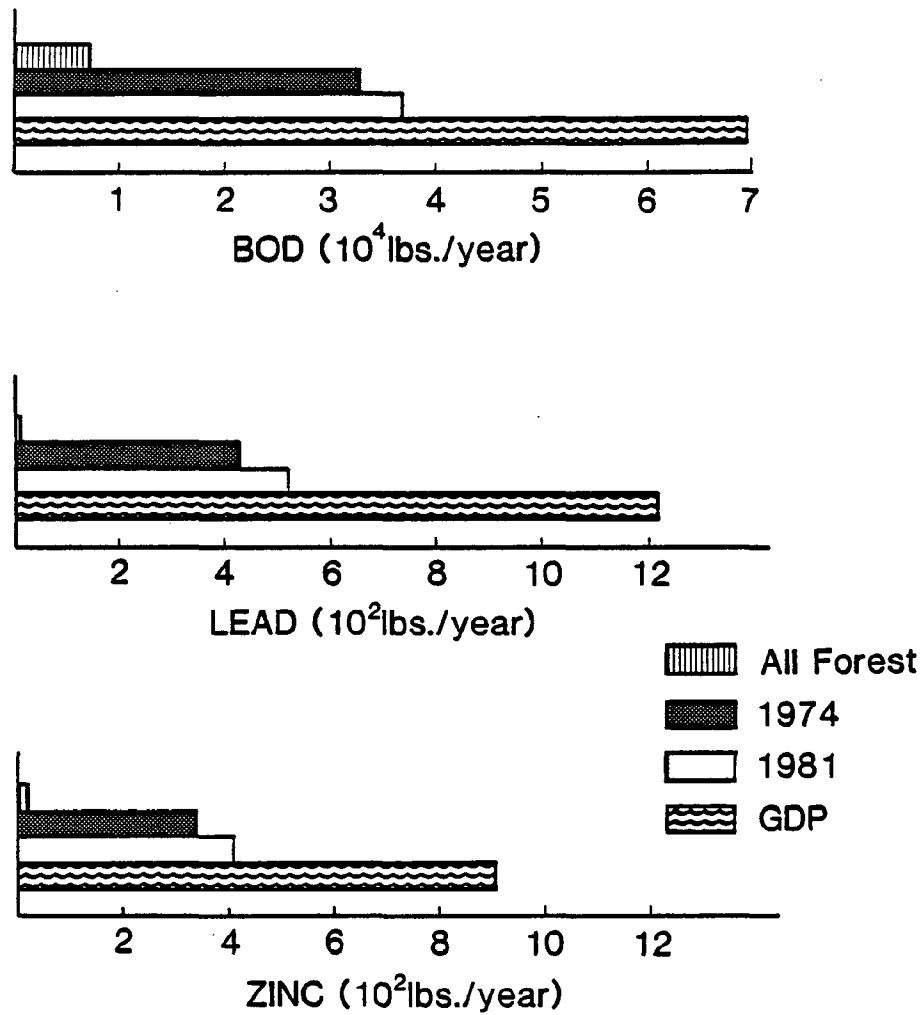


Figure 20.
Total Pollutant Loading from
Church Creek Watershed (BOD,Lead, Zinc)

2. Each car gets 20 miles/gallon.

The estimated yearly production of lead from automobiles L_A is then given by

$$L_A = \left(\frac{5 \text{ mi}}{20 \text{ mi/gal}} \right) \left(2.5 \frac{\text{g lead}}{\text{gal}} \right) (.5) \left(2.2 \times 10^{-3} \frac{\text{lbs}}{\text{g}} \right) \left(23,000 \frac{\text{cars}}{\text{day}} \right) \left(365 \frac{\text{days}}{\text{yr}} \right)$$

$$L_A = 5,000 \text{ lbs lead/year}$$

According to the Illinois study a large fraction of the lead accumulates in the surface soil near the highways. Stormwater runoff from the highways will transfer some of this lead to Church Creek. If we compare the admittedly rough estimate of yearly lead loadings from traffic (5,000 lbs) with the total lead loading estimate from the watershed (450 lbs), it suggests that vehicle traffic may be a major source of lead within the Church Creek watershed. Similar arguments may hold true for zinc because the major source of the zinc loading is thought to be the wear of automobile tires. At the least, the contributions of vehicle traffic to heavy metal pollution in the Church Creek watershed should be further investigated.

Another process that is not accounted for in these calculations is the disturbance and exposure of soil at construction sites or new road construction. At present there are no good procedures for estimating the nutrient and pollutant discharges from construction sites. The reason for this is the uniqueness of each construction site in terms of land disturbance, sediment control practices, intensity and duration of storms that occurred while bare soil was exposed, etc. Because construction activity has been neglected in our model the estimated loadings are probably conservative.

V. IMPACT OF NUTRIENT AND POLLUTANT LOADINGS ON CHURCH CREEK

In the previous section we have obtained estimates of yearly nutrient and pollutant loadings from the Church Creek watershed. In this section we discuss the following questions:

1. What happens to these nutrients and pollutants once they enter Church Creek?
2. What impact do these nutrients and pollutants have on the water quality of Church Creek?

The first question cannot be answered without a thorough physical, chemical, and biological study of Church Creek. Even if this were available, many of the chemical and biological interactions that control the transport of nutrients and pollutants within an estuary are still not completely understood. This is particularly true of the water-sediment interface at the bottom of the creek.³⁸

The second question is not answerable at the present time. There is insufficient scientific knowledge to predict the amount of a particular nutrient or pollutant that will cause a decline in the water quality of an estuary.³⁹ There is not even a consensus among scientists as to the proper choice of variables required to define the water quality of an estuary.⁴⁰⁻⁴²

What then can land use planners or water quality managers do to get some perspective of the effects of nutrient and pollutant loadings on an estuary such as Church Creek? The best that can be done with limited resources is to use some of the simplified methods that have been developed to estimate water circulation, biochemical transport, and water quality within an estuary.

Detailed computer models have been developed in an attempt to simulate the physical, chemical, and biological processes occurring in an estuary.⁴³⁻⁴⁵ Because of the complexity of the problem, most of the work has been done using one or two dimensional models--that is, these models only account for processes that vary in one or two directions while assuming all variables are constant in the other directions. A one dimensional model, for example, assumes that the estuary has a uniform cross section.

The topography of Church Creek is shown in the bathymetry map, Figure 21. This map is part of a hydrographic survey map, number 5329, done by the U. S. Coast and Geodetic Survey in 1933. The soundings shown are in feet at mean low water. This is the latest survey done on Church Creek. Undoubtedly tidal action and silting have changed some of the indicated depths, but for purposes of rough estimates it will suffice. Cross sections of the creek and the distribution of water at mean low tide within the creek are shown in Figure 22. About 78% of the water is contained between the mouth and a point approximately half way up the creek. A longitudinal profile taken along the center of the channel is shown in Figure 23.

Because of varying cross sections of Church Creek, estimates of water circulation and pollutant concentration based on a one dimensional model would likely be misleading. However, rough estimates can be made of the flushing time of the creek. The flushing time is time required to replace the water in the creek with water from other sources, either fresh water inflow from the watershed or tidal water from the South River.

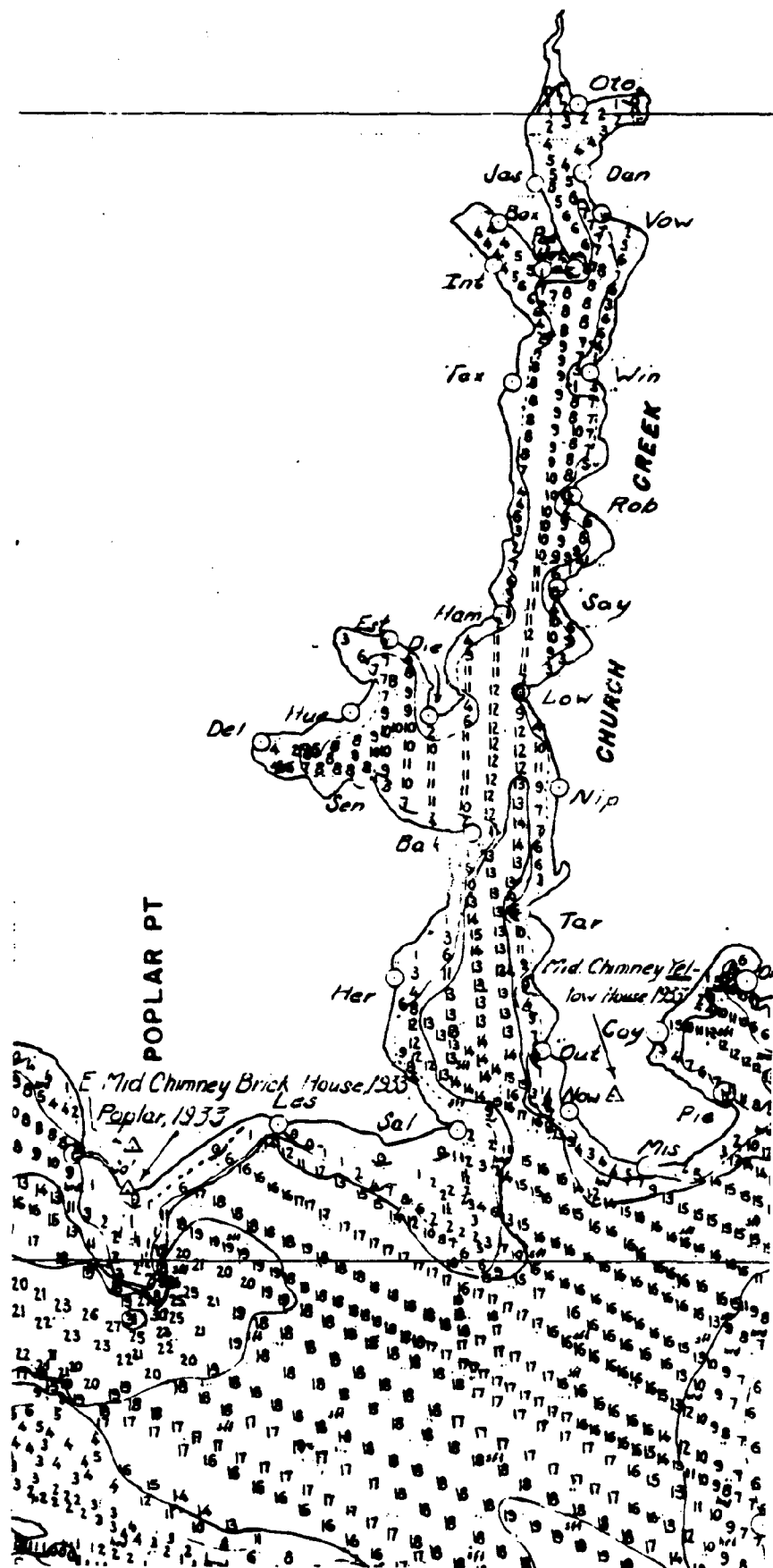


Figure 21. Church Creek Bathymetry



CHURCH CREEK LONGITUDINAL PROFILE

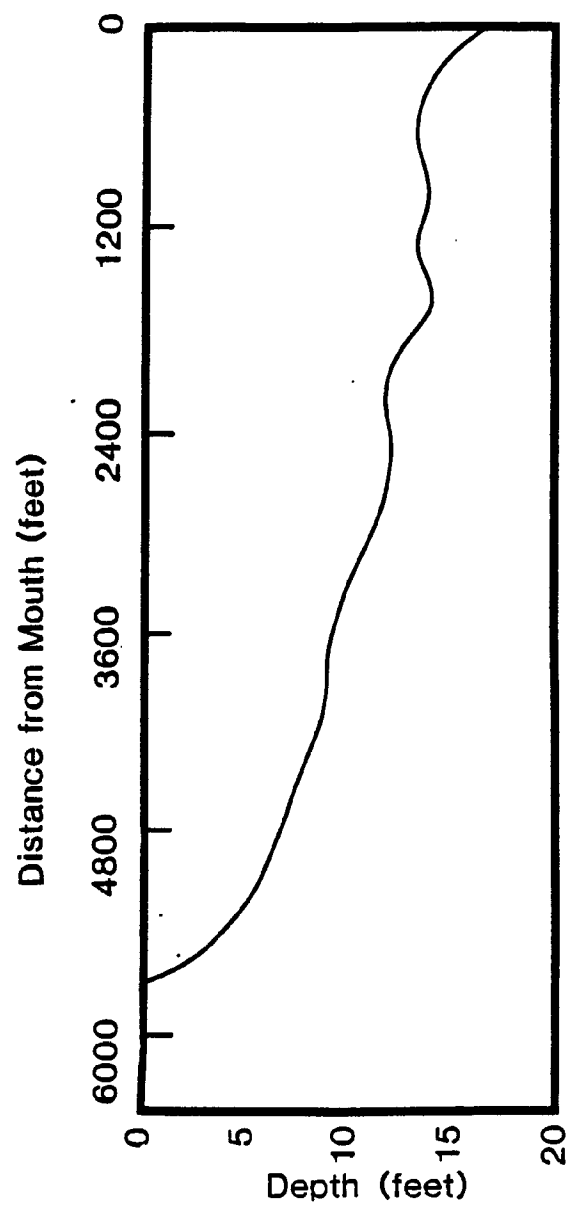


Figure 23. Church Creek Longitudinal Profile

A rough estimate of the flushing time is given by the expression^{46,12}

$$T_F = \frac{V + P}{P}$$

where

T_F = flushing time (tidal cycles)

V = volume of water in the estuary at mean low tide (ft³)

P = intertidal volume (ft³)

The intertidal volume was calculated by multiplying the average tidal height, which for the South River is .89 feet,⁴⁷ by the surface area of the creek as shown on the bathymetric map (Figure 21). This gave an intertidal volume of 2.8×10^6 ft³.

The volume of water in the estuary at mean low tide was found by drawing a series of transverse cross sections of the creek. A planimeter was used to find the areas of these cross-sections and then the average area of two adjacent cross sections was multiplied by the average depth between the cross sections. The total volume of water found in this way is 24.7×10^6 ft³. The estimated flushing time obtained by this method is 8.7 tidal cycles, or taking a tidal cycle equal to 12.4 hours results in a flushing time estimate of 4.5 days.

Another method for estimating flushing times as described by Zison et al.¹² is the modified tidal prism method. In this approach the estuary is segmented so that each segment length represents the excursion distance a particle can travel during one tidal cycle. The first segment, located at the head of the creek, must therefore have an intertidal volume that is completely supplied by fresh water flow from the watershed.

Let P_i represent the intertidal volume of segment i . The first intertidal volume P_0 can be estimated by combining the average fresh water flow from subwatersheds 3, 4 and 5. The average yearly rainfall is 48 inches/year,⁴⁸ so that on the average 6.8×10^{-2} inches of rain falls on the watershed per tidal cycle. If we assume that 50% of this rain water reaches the estuary, then the average flow rate from subwatersheds 3, 4 and 5 is $9 \times 10^4 \text{ ft}^3/\text{tidal cycle}$. Thus P_0 is equal to $9 \times 10^4 \text{ ft}^3$.

Let V_i represent the low tide volume of the segment i . The low tide volume V_0 can be found because it lies under the intertidal volume P_0 which occupies a volume $P_0 = d W_0 L_0$, where d is height of tide, W_0 is the width of the segment, and L_0 is the length of the segment. From the survey map $W_0 = 360$ feet and d is the height of tide, .89 feet. Therefore $L_0 = 282$ feet. Once the length L_0 of the initial segment is known the volume V_0 is found by

$$V_0 = W_0 L_0 d_{av} = (360)(282)(3) = 304,000 \text{ ft}^3$$

where d_{av} is the average water depth of this segment. An exchange ratio r_0 can now be calculated

$$r_0 = \frac{P_0}{P_0 + V_0} = \frac{9 \times 10^4}{9 \times 10^4 + 30 \times 10^4} = .231/\text{tidal cycle}$$

From this the flushing time for this segment is

$$T_{F_0} = \frac{1}{r_0} = 4.3 \text{ tidal cycles}$$

Now for the next segment the low tide volume is found using the expression $V_1 = P_0 + V_0$. Once V_1 is known then the length of this

segment L_1 can be calculated, from which the intertidal volume P_1 , the exchange ratio r_1 , and segment flushing time T_{F_1} can be calculated. The procedure is repeated for as many segments as are needed to reach the mouth of the creek. The flushing time for the creek is then the sum of the flushing times of each segment.

The results of this modified tidal prism method for Church Creek give a flushing time of 50 days for the water to travel 3,300 feet from the head of the creek. This long flushing time is primarily due to the low average fresh water input to the creek. If an extended storm were to deliver a significant amount of water over a few days, then the flushing time would be greatly reduced. This calculation does point out that during extended dry periods tidal action is not very effective in flushing the upper half of the creek.

The circulation of water within an estuary is not only due to fresh water input and tides. Wind stresses and density variations due to salinity gradients can be important factors in determining the amount and location of mixing in estuaries.⁴⁵ The hydrologic map (Figure 21) and the creek cross sections (Figure 22) show a broadening of Church Creek at a distance of 2000 feet from the mouth. This large surface area makes it likely that wind driven circulation is important in this part of the creek.

The estimated flushing times indicate that it is possible for nutrients and pollutants that are introduced from the watershed to spend a significant time within Church Creek. The concentration of these nutrients and pollutants depends upon a series of complex,

interrelated physical, chemical and biological processes. For example, it has been found that the amount and type of organic compounds in the water determine the fraction of lead that is transferred from sediment particles to the water.⁴⁹

The impact of nutrient enrichment on an estuary and corresponding management implications are discussed in an excellent collection of review articles edited by Neilson and Cronin.⁵⁰ The overall sense of these reviews is that while a great deal has been learned about nutrient cycling within an estuary, much still remains to be discovered.

With the present state of knowledge of estuarine ecology, what method can planners use to establish reasonable patterns of land use within a watershed? We suggest that the ratios R_i , where

$$R_i = \frac{\text{total loading of pollutant } i \text{ from watershed (lbs/year)}}{\text{total loading of pollutant } i \text{ for completely forested watershed (lbs/year)}}$$

be used as the index of the state of the watershed. If there is a correlation between the "health" of an estuary and these pollutant ratios, then maximum ratio values could be assigned based on comparison of several watersheds within a county. For this purpose the "health" of an estuary could be based on fairly broad criteria, such as water clarity, odor production, dissolved oxygen history, etc. Adjustments to the maximum ratios may be needed to account for factors such as flushing time and quality of benthic material.

These maximum ratio values could be used as guidelines in the establishment of general development plans for a watershed. Admittedly the establishment of maximum loading ratios is not a trivial task and

is well beyond the scope of work reported here. We offer it as a suggestion that we believe is reasonable and within the resources of local government agencies. Planning guidelines based on watershed characteristics will focus the attention of both planners and citizens on the ecological unit that often determines the health of an estuary--its watershed.

VI. DISCUSSION AND RECOMMENDATIONS

Loading estimates for the Church Creek watershed illustrate three important influences of land use on the water quality of an estuary. First, the importance of agricultural practices is shown by the reduction in sediment loading because of the change from conventional crop to minimum tillage farming. Second, the large amount of biological oxygen demand (BOD) from commercial and high density residential land use, when coupled with excess nitrogen and phosphorous input, is likely to lower the dissolved oxygen concentration in the estuary during the summer months. Excess nitrogen and phosphorous promote algae growth which when it dies sinks to the bottom and becomes another source of BOD. This BOD along with the BOD load from the watershed is likely to increase the length of time during which the dissolved oxygen level is below 5 parts per million, the level usually regarded as necessary to sustain fish and other important aquatic organisms. Third, commercial areas are important sources of heavy metals, such as lead and zinc.

As a result of the work reported here we offer the following recommendations:

1. State and federal agencies should be encouraged to support the monitoring of single use subwatersheds in the Chesapeake Bay region over long time periods (5 year minimum) by qualified agencies, such as the Smithsonian's Chesapeake Bay Center for Environmental Studies or the Baltimore Regional Planning Council's monitoring division. The goal of this work would be to produce a larger data base from which improved loading factor values would be obtained.

Additional long term monitoring data are also needed to evaluate best management practices (holding ponds, pervious surfaces, etc.) applied to commercial land use. This will provide loading factors that allow local jurisdictions to evaluate the relative impact of different scenarios of best management practices.

2. WATER SCREEN be used by local jurisdictions to evaluate watersheds that are under heavy development pressure. Comparison of the loading estimates of different watersheds will help to establish management priorities and provide a criterion for the allocation of funds and planning efforts.
3. The contribution of vehicle traffic to nutrient and pollutant loadings in small watersheds, such as Church Creek, should be investigated. Development of loading factors based on daily traffic volume would be useful.
4. The need for implementing pollution control measures for highly impervious land uses, such as Commercial Development, has been indicated in this study. Stormwater management techniques which reduce the pollutant load carried in runoff should be mandated for these sites. The large BOD loading should particularly be addressed with best management practices that would remove these pollutants. The effectiveness of street sweeping and other general housekeeping measures for reduction of the available pollutants should be explored for areas of high imperviousness.

5. This study has estimated that a large amount of pollution may be transported to Church Creek in stormwater runoff from existing highly impervious areas. The possibility of adding pollution control measures to existing storm drainage systems or the installation of a regional facility to reduce these pollutant loads should be considered by decision makers. The Department of Natural Resources is funding a flooding study of the Church Creek watershed. Stormwater management techniques which may be evaluated during this study should have pollution reduction capabilities.

*** A reviewer has pointed out that the medium density land use (56.7 acres) in subwatershed 2 listed in Table 3 is not correct. The GDP map indicates this area as high density land use. A recalculation of the total GDP pollutant loadings using the correct land use assignment increases the estimates shown in Figures 19 and 20 by only 1 to 2%. This correction does not change any of the conclusions in this report.

REFERENCES

1. Swank, R. R., "U. S. Environmental Protection Agency Program On Nonpoint Source Modeling," in Environmental Impact of Nonpoint Source Pollution, M. R. Overcash and J. M. Davidson, eds., (Ann Arbor Science, 1980), p. 1.
2. Simons, D. B. and R. Li, "Modeling of Sediment Nonpoint Source Pollution from Watersheds," in Environmental Impact of Nonpoint Source Pollution, M. R. Overcash and J. M. Davidson, eds., (Ann Arbor Science, 1980), p. 341.
3. Donigian, A. and N. Crawford, "Modeling - Nonpoint Pollution from the Land Surface," EPA 600/3-76-083, EPA, Athens, GA., July, 1976.
4. Johanson, R. C., J. C. Imhoff, and H. Davis, "Users Manual for Hydrological Simulation Program - FORTRAN (HSPF)," EPA 600/9-80-015, EPA, Athens, GA., April, 1980.
5. Russell, C. S., ed., Ecological Modeling in a Resource Management Framework, Resources for the Future, Inc., (Johns Hopkins University Press, July, 1975).
6. Huber, W. C. and J. P. Heaney, "Operational Models for Stormwater Quality Management," in Environmental Impact of Nonpoint Source Pollution, M. R. Overcash and J. M. Davidson, eds., (Ann Arbor Science, 1980), p. 397.
7. Holtan, H. N., J. P. Ormsby, and G. T. Fisher, "Applications of a Maryland Version of USDAHL-74 to a Watershed in Prince George's County, Maryland," in Watershed Research in Eastern North America, D. L. Correll, ed., (Chesapeake Bay Center for Environmental Studies, Smithsonian Institution, 1977).

8. Thomann, R. and T. Barnwell, Jr., Co-chairmen, Workshop on Verification of Water Quality Models, EPA 600/9-80-016, EPA, Athens, GA., 1980.
9. Northern Virginia Planning District Commission, "Guidebook for Screening Urban Nonpoint Pollution Management Strategies," prepared for Metropolitan Washington Council of Governments, Washington, D. C., November, 1979.
10. Northern Virginia Planning District Commission and Virginia Polytechnic Institute and State University, "Occoquan/Four Mile Run Nonpoint Source Correlation Study," Final Report prepared for Metropolitan Washington Council of Governments, Washington, D. C., July, 1978.
11. Northern Virginia Planning District Commission, "Washington Metropolitan Area Urban Runoff Demonstration Project," Final Report prepared for Metropolitan Washington Council of Governments, Washington, D. C., April, 1983.
12. Zison, S. W., K. F. Haven, and W. B. Mills, "Water Quality Assessment - A Screening Method for Nondesignated 208 Areas," EPA 600/9-77-023, EPA, Athens, GA., 1977.
13. Davis, M. J., M. K. Snyder, and J. W. Nebgen, "River Basin Validation of the Water Quality Assessment Methodology for Screening Nondesignated 208 Areas. Volume I: Nonpoint Source Load Estimation," EPA 600/3-82-057a, EPA, Athens, GA., 1982.

14. Dean, J. D., B. Hudson, and W. B. Mills, "River Basin Validation of the Water Quality Assessment Methodology for Screening Non-designated 208 Areas, Volume II: Chesapeake-Sandusky Nondesignated 208," EPA 600/3-82-057b, EPA, Athens, GA., 1982.
15. Wischmeier, W. H., "A rainfall erosion index for a universal soil-loss equation," Soil Sci. Soc. Amer. Proc. 23: 246-249 (1959).
16. Stephens, H., "Guide for Predicting Rainfall-Erosion Losses from Agricultural Land in Maryland and Delaware," Technical Note Conservation Planning 1-78, Soil Conservation Service, USDA, College Park, Maryland, July, 1978.
17. "Erosion and Sediment Survey of Baltimore Regional Planning Council Area," prepared by Soil Conservation Service, USDA, College Park, Maryland, for Baltimore Regional Planning Council, December, 1977.
18. Foster, G. R., "Soil Erosion Modeling: Special Considerations for Nonpoint Pollution Evaluation of Field Sized Areas," in Environmental Impact of Nonpoint Source Pollution, M. R. Overcash and J. M. Davidson, eds., (Ann Arbor Science, 1980), p. 213.
19. Logan, T. J., "The Role of Soil and Sediment Chemistry in Modeling Nonpoint Sources of Phosphorous," in Environmental Impact of Nonpoint Source Pollution, M. R. Overcash and J. M. Davidson, eds., (Ann Arbor Science, 1980), p. 189.
20. USEPA Chesapeake Bay Program, "Monitoring Studies of Nonpoint Pollution in Chesapeake Bay Test Watersheds: Final Completion Report," U. S. Environmental Protection Agency, Annapolis, Maryland, (In Press).

21. Bosco, C., G. F. Anderson, and B. Neilson, "Ware River Intensive Watershed Study. 2. Estuarine Receiving Water Quality," final report to Virginia State Water Control Board, (Virginia Institute of Marine Science, Gloucester Point, Virginia), July, 1982.
22. Weand, B., and T. Grizzard, "Evaluation of Management Tools in the Occoquan Watershed," final report to Virginia Water Control Board, (Occoquan Watershed Monitoring Laboratory, Virginia Polytechnic Institute and State University, Manassas, Virginia), 1982.
23. Bostater, C., D. McCraney, S. Berlett, and D. Puskar, "Intensive Watershed Study - The Patuxent River Basin," final report to EPA Chesapeake Bay Program, (Maryland Department of Natural Resources, Annapolis, Maryland), 1983.
24. Hartigan, J. P., T. F. Quasebarth, and E. Southerland, "Use of Continuous Simulation Model Calibration Techniques to Develop Nonpoint Pollution Loading Factors," Proceedings of Stormwater and Water Quality Management Modeling Users Group Meeting: March 25-26, 1982, EPA 600/9-82-015, U. S. Environmental Protection Agency, Athens, GA., 1982, p. 101.
25. Kirby, R. and E. D. Matthews, "Soil Survey of Anne Arundel County, Maryland," Soil Conservation Service, U. S. Department of Agriculture, 1973.
26. Lombardi, F., "Universal Soil Loss Equation (USLE), runoff erosivity factor, slope length exponent, and slope steepness exponent for individual storms," Ph.D. thesis, Purdue University, West Lafayette, Indiana, 1979.

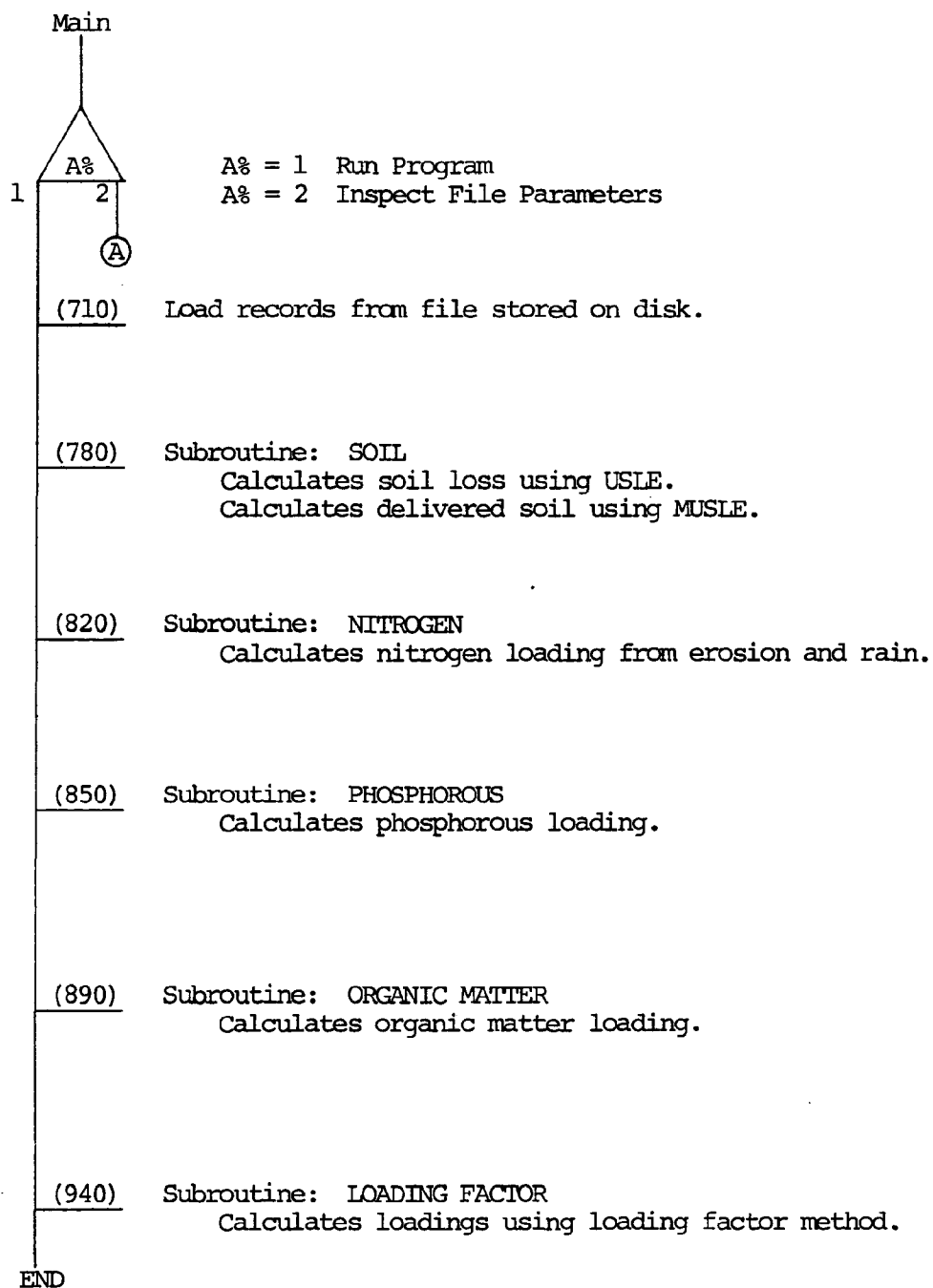
27. Lane, L. J., D. A. Woolhiser, and V. Yevjevich, "Influence of simplification in watershed geometry on simulation of surface runoff," Hydrology Paper No. 81, Colorado State University, Fort Collins, Colorado, 1975.
28. Foster, G. R., and W. H. Wischmeier, "Evaluating irregular slopes for soil loss prediction," Trans. of ASAE 17, 2: 305-309 (1974).
29. Young, R. A., and C. K. Mutchler, "Effect of slope shape on erosion and runoff," Trans. of the ASAE 12, 2: 231-233 (1969).
30. Stephens, H. V., H. E. Scholl, and J. W. Gaffney, "Use of the Universal Soil Loss Equation in Wide-Area Soil Loss Surveys in Maryland," in Soil Erosion Prediction and Control, Special Publication No. 21, Soil Conservation Society of America, (1976), p. 277.
31. Roffe, K. A., "Computerized Mapping for Assessment of Environmental Impacts: A Case Study," Annual Conference of the American Institute of Planners, October, Kansas City, Missouri, 1977.
32. Nielsen, D. R., and J. G. MacDonald, eds., Nitrogen in the Environment, Vol. 1. Nitrogen Behavior in Field Soil, (Academic Press, 1978).
33. Tanji, Kenneth, "Problems in Modeling Nonpoint Sources of Nitrogen in Agricultural Systems," in Environmental Impact of Nonpoint Source Pollution, M. R. Overcash and J. M. Davidson, eds., (Ann Arbor Science, 1980), p. 165.

34. Correll, D. L., T. L. Wu, E. S. Friebele, and J. Miklas, "Nutrient Discharge from Rhode River Watersheds and Their Relationship to Land Use Patterns," in Watershed Research in Eastern North America, Vol. 1, D. L. Correll, ed., (Chesapeake Bay Center for Environmental Studies, Edgewater, Maryland, 1977), p. 413.
35. Pierce, J. W., and F. T. Dulong, "Discharge of Suspended Particulates from Rhode River Subwatersheds," in Watershed Research in Eastern North America, Vol. 2, D. L. Correll, ed., (Chesapeake Bay Center for Environmental Studies, Edgewater, Maryland, 1977), p. 531.
36. State of Maryland Traffic Volume Map, Maryland Department of Transportation, 1981.
37. Rolfe, G. L., and J. C. Jennett, "Environmental Lead Distribution in Relation to Automobile and Mine and Smelter Sources," Heavy Metals in the Aquatic Environment, P. A. Krenkel, ed., (Pergamon, 1975), p. 231.
38. Baker, R. A., ed., Contaminants and Sediments, Vol. 1 and 2, (Ann Arbor Science, 1980)
39. Biggs, R. B., and L. E. Cronin, "Special Characteristics of an Estuary," in Estuaries and Nutrients, B. J. Neilson and L. E. Cronin, eds., (Humana Press, 1981), p. 3.
40. Ott, W. R., Environmental Indices, Theory and Practice, (Ann Arbor Science, 1978).
41. McErlean, A. J., and G. Reed, "Indicators and Indices of Estuarine Enrichment," in Estuaries and Nutrients, B. J. Neilson and L. E. Cronin, eds., (Humana Press, 1981), p. 165.

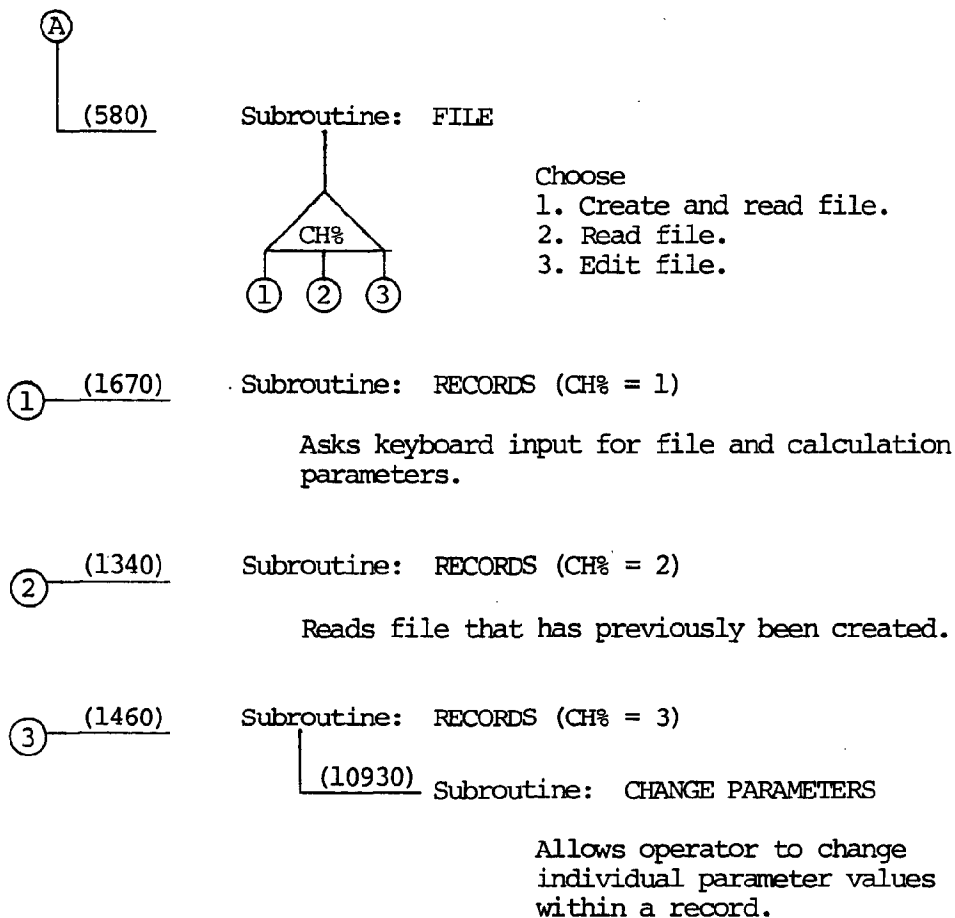
42. Jaworski, N. A., and O. Villa, Jr., "A Suggested Approach for Developing Water Quality Criteria for Management of Eutrophication," in Estuaries and Nutrients, E. J. Neilson and L. E. Cronin, eds., (Humana Press, 1981), p. 499.
43. Sündermann, J., and K. P. Holz, eds., Mathematical Modeling of Estuarine Physics, Vol. 1 of Lecture Notes on Coastal and Estuarine Studies, (Springer-Verlag, 1980).
44. O'Conner, D. J., "Modeling of Eutrophication in Estuaries," in Estuaries and Nutrients, E. J. Neilson and L. E. Cronin, eds., (Humana Press, 1981), p. 183.
45. Fischer, H. B., E. J. List, R. C. Y. Koh, J. Imberger, and N. H. Brooks, Mixing in Inland and Coastal Waters, (Academic Press, 1979).
46. Dyer, K. R., Estuaries: A Physical Introduction, (Wiley, 1973).
47. Cronin, W. B., "Volumetric, Areal, and Tidal Statistics of the Chesapeake Bay Estuary and Its Tributaries," Special Report 20, Reference 71-2, Chesapeake Bay Institute, Johns Hopkins University, 1971.
48. Loates, H., Jr., T. Fowler, and P. Castruccio, "Applications of Remote Sensing to Hydrologic Planning," NASA Contractor Report 3041, National Aeronautics and Space Administration, 1978.
49. De Groot, A. J., and E. Allersma, "Field Observations of the Transport of Heavy Metals in Sediments," in Heavy Metals in the Aquatic Environment, P. A. Krenkel, ed., (Pergamon, 1975), p. 85.
50. Neilson, B. J., and L. E. Cronin, eds., Estuaries and Nutrients, (Humana Press, 1981).

APPENDIX A

A logic diagram for the major subsections of WATER SCREEN is shown below.
(The numbers in parentheses are program line numbers.)



APPENDIX A



Line 430 contains the variable NSUB% and NTYPE%. NSUB% is the number of subwatersheds and NTYPE% is the number of land uses. To change the number of subwatersheds just change the value of NSUB%. If more than 7 subwatersheds are needed, then some of the variables will have to have their dimensions changed in lines 310 through 350. Note that in the program NR% = NSUB% and NC% = NTYPE%.

Because of the logic used in the program it is quite easy to add or delete subroutines that use different methods of calculating nutrient and pollutant loadings and to add or delete the corresponding records that contain the parameters used in the calculation. Commercially available utility programs, such as Apple Doc, are very helpful in this process.

APPENDIX B

LIST

```

100 PRINT "XXXXXXXXXXXXXXXXXXXXXXXXXXXXX"
110 PRINT "X"
120 PRINT "X"
130 PRINT "X          WATER SCREEN          X"
132 PRINT "X"
134 PRINT "X      (FILE,USLE,LOADING FACTOR)  X"
136 PRINT "X"
140 PRINT "X"
150 PRINT "X          VERSION 2.0          X"
160 PRINT "X"
170 PRINT "X              BY              X"
180 PRINT "X"
190 PRINT "X          BRUCE BIRD          X"
200 PRINT "X"
210 PRINT "XXXXXXXXXXXXXXXXXXXXXXXXXXXXX"
220 REM
230 REM
240 REM
250 REM XXXXXXXXXXXXXXXXXXXXXXXX
260 REM X      MAIN      X
270 REM XXXXXXXXXXXXXXXXXXXXXXXX
280 REM
290 REM
300 REM
310 DIM AR(7,11),REC$(20),NO$(20),SW$(15),LAR(7,11),UV(7,7),DIR$(20)
320 DIM A$(10),KF(7,7),LF(7,7),SF(7,7),CF(7,7),PF(7,7),SD(7,7),HF(6,1
1),LF$(6)
330 DIM IN$(20),RS$(30),RG$(30),F1$(30)
340 DIM SL(7,7),DD(7,7),SQ(7),DQ(7),LL(7),LD(7),NLE(7),NWS(7),LU(7),N
QR(7),LW(7),NPR(7)
350 DIM NTL(7),NST(7),PL(7),PW(7),ML(7),MW(7),OL(7),OW(7),PM(7,11),PI
(7,11),OM(5),PC(5),PA(11)
355 REM READ FIELD LENGTHS FOR EACH RECORD GROUP
356 DATA 40,8,2,8,40,8,8,8,8,8,8,8,8,8,8
357 FOR I = 0 TO 14: READ F1$(I): NEXT I
360 REM SW$(I) USED WITH INPUT FOR USLE PARAMETERS
370 SW$(1) = "FOREST"
380 SW$(2) = "PASTURE":SW$(3) = "HAYFIELD":SW$(4) = "CONVENTIONAL CROP
":SW$(5) = "MINIMUM TILLAGE CROP":SW$(6) = "IDLE"
390 SW$(7) = "LOW DENSITY RESIDENTIAL":SW$(8) = "LOW/MED DENSITY RESID
ENTIAL":SW$(9) = "MEDIUM DENSITY RESIDENTIAL":SW$(10) = "HIGH DENSITY
RESIDENTIAL":SW$(11) = "COMMERCIAL"
400 REM
410 LF$(1) = "SEDIMENT":LF$(2) = "TOTAL NITROGEN":LF$(3) = "TOTAL PHOS
PHOROUS"
420 LF$(4) = "BOD":LF$(5) = "LEAD ":LF$(6) = "ZINC"
425 REM NSUB% = NO. OF SUBWATERSHEDS, NTYPE% = NO. OF LAND USES
430 NSUB% = 6:NTYPE% = 11:TG% = 15:RL% = 40
440 D$ = CHR$(4):I$ = CHR$(9)
450 REM
460 REM <<< CHOOSE OPTIONS >>>
470 REM
480 HOME
490 PRINT "*** OPTIONS ***": PRINT : PRINT
500 PRINT "CHOOSE:": PRINT

```

```

510 PRINT " 1 RUN PROGRAM ": PRINT
520 PRINT " 2 INSPECT PARAMETERS": PRINT
530 INPUT "OPTION NUMBER = ?";A%: PRINT : PRINT
532 INPUT "DO YOU WANT PRINTED COPY OF INPUT DATA FILE?(Y OR N)";A$
534 PC% = 1
536 IF A$ = "Y" THEN PC% = 2
540 ON A% GOTO 620,580
550 REM
560 REM <<< GO SUB:FILE >>>
570 REM
580 GOSUB 1050
590 PRINT D$;"PR#0"
600 GOTO 730
610 REM START PROGRAM
620 HOME
630 PRINT "   *** INPUT ***": PRINT : PRINT
640 INPUT "FILE NAME = ?";NAME$
650 REM
660 REM TRANSFER FILE TO VARIABLES
670 REM GOSUB:RECORDS
680 REM OPT%=2 : READ AND LOAD ONLY
690 REM
700 OPT% = 2:ID$ = NAME$
710 GOSUB 1670
720 PRINT D$;"CLOSE"
730 INPUT "DO YOU WANT TO RUN THE PROGRAM ? ( Y OR N)";A$
740 IF A$ = "N" GOTO 950
741 REM
742 REM GOSUB: PRINTER CODE 1
743 REM
744 GOSUB 12955
750 REM
760 REM GOSUB: SOIL
770 REM
780 GOSUB 20070
790 REM
800 REM GOSUB: NITROGEN
810 REM
820 GOSUB 21040
830 REM
840 REM GOSUB: PHOSPHOROUS
850 REM
860 GOSUB 24270
870 REM
880 REM GOSUB: ORGANIC MATTER
890 REM
900 GOSUB 24980
910 REM
915 IF NO%(1) = 2 GOTO 950: REM MUSLE ONLY OPTION
920 REM GOSUB: LOADING FACTORS
930 REM
940 GOSUB 25634
945 REM
947 REM GOSUB: PRINTER CODE 2
950 GOSUB 12965
958 PRINT D$;"PR#0"
960 END
970 REM
980 REM
990 REM *****

```

```

1000 REM          SUBROUTINE FILE
1010 REM  *****
1020 REM
1030 REM
1040 REM
1050 HOME
1060 REM
1070 REM  <<< OPTIONS >>>
1080 REM
1090 HOME
1100 PRINT "   *** OPTIONS ***": PRINT : PRINT
1110 PRINT "CHOOSE:": PRINT
1120 PRINT "   1 CREATE AND READFILE": PRINT
1130 PRINT "   2 READ FILE ": PRINT
1140 PRINT "   3 EDIT FILE ": PRINT
1150 INPUT "OPTION NUMBER =?";CH%
1160 ON CH% GOTO 1220,1340,1460
1170 REM
1180 REM  <<< CREATE AND READ FILE>>>
1190 REM
1200 REM  <<< INPUT FILE NAME >>>
1210 REM
1220 HOME
1230 PRINT "   *** INPUT ***": PRINT : PRINT
1240 INPUT "FILE NAME =?";NAME$
1250 REM
1260 REM  <<< GO SUB: RECORDS >>>
1270 REM
1280 ID$ = NAME$:OPT% = CH%
1290 GOSUB 1670
1300 GOTO 1580
1310 REM
1320 REM  <<< READ FILE>>>
1330 REM
1340 HOME
1350 PRINT "   *** READ FILE *** ": PRINT : PRINT
1360 INPUT "FILE NAME = ?";NAME$
1370 REM
1380 REM  <<< GOSUB:RECORDS>>>
1390 REM
1400 ID$ = NAME$:OPT% = CH%
1410 GOSUB 1670
1420 GOTO 1580
1430 REM
1440 REM  <<< EDIT RECORD GROUP >>>
1450 REM
1460 HOME : PRINT "*** EDIT FILE ***": PRINT : PRINT
1470 INPUT "FILE NAME = ?";ID$
1480 PRINT D$;"OPEN"ID$,"L40"
1490 REM
1500 REM  <<< READ FILE PARAMETERS >>>
1510 REM
1520 REM  <<< GOSUB: RG2 >>>
1530 GOSUB 3220
1540 REM
1550 REM  <<< GOSUB: CHANGE PARAMETERS >>>
1560 REM
1570 GOSUB 10930
1580 PRINT D$;"CLOSE"
1590 RETURN

```



```

1600 REM
1610 REM *****
1620 REM      SUBROUTINE RECORDS
1630 REM *****
1640 REM
1650 REM
1660 REM
1670 PRINT D$;"OPEN"ID$,"L40"
1690 ID$ = NAME$:PT% = OPT%
1700 REM
1710 REM      GOSUB: RG0      (FILE INFORMATION)
1720 REM
1730 GOSUB 2440
1740 REM
1750 REM      GOSUB: RG1      (FILE NUMBERS)
1760 REM
1770 GOSUB 2970
1780 REM
1790 REM      GOSUB: RG2      (CALCULATION OPTIONS)
1800 REM
1810 GOSUB 3560
1820 REM      GOSUB: RG3      (LAND USE AREAS)
1830 GOSUB 4350
1840 REM
1850 REM      GOSUB: RG4      (RAINFALL FACTOR)
1860 REM
1870 GOSUB 5040
1880 REM
1890 REM      GOSUB: RG5      (ERODIBILITY FACTOR)
1900 REM
1910 GOSUB 5400
1920 REM
1930 REM      GOSUB: RG6      (LENGTH FACTOR)
1940 REM
1950 GOSUB 6020
1960 REM
1970 REM      GOSUB: RG7      (SLOPE FACTOR)
1980 REM
1990 GOSUB 6660
2000 REM
2010 REM      GOSUB: RG8      (COVER FACTOR)
2020 REM
2030 GOSUB 7070
2040 REM
2050 REM      GOSUB: RG9      (PRACTICES FACTOR)
2060 REM
2070 GOSUB 7530
2080 REM
2090 REM      GOSUB: RG10     (SEDIMENT DELIVERY RATIO)
2100 REM
2110 GOSUB 7950
2120 REM
2130 REM      GOSUB: RG11     (NITROGEN)
2140 GOSUB 8380
2150 REM
2160 REM      GOSUB: RG12     (PHOSPHOROUS)
2170 REM
2180 GOSUB 9000
2190 REM
2200 REM      GOSUB: RG13     (ORGANIC MATTER)

```

```

2210 REM
2220 GOSUB 9520
2230 REM
2240 REM      GOSUB: RG14      (LOADING FACTOR)
2250 REM
2260 GOSUB 10020
2270 REM
2280 REM
2290 REM      <<< GO SUB: RG1 >>>
2300 REM
2310 REM      STORE FINAL FILE PARAMETERS IN RG1
2320 GOSUB 3060
2330 RETURN
2340 REM
2350 REM
2360 REM      *****
2370 REM      INDIVIDUAL RECORD SUBROUTINES
2380 REM      *****
2390 REM
2400 REM
2410 REM      *****
2420 REM      *      SUB:RG0      *
2430 REM      *****
2440 RI% = 0:RS%(0) = RI%
2450 ON PT% GOTO 2490,2740,2490
2460 REM
2470 REM      <<< INPUT FOR RECORD GROUP 0 >>>
2480 REM
2490 HOME
2500 IN$(0) = "WATER SCREEN (FILEXUSLEXL) VER 2.0"
2510 IN$(1) = "RECORD LENGTH= 40 "
2520 PRINT "      *** PROGRAM AND FILE INFORMATION ***": PRINT : PRINT
2530 PRINT "RECORD GROUP NUMBER 0 ": PRINT
2540 INPUT "RIVER NAME=?";IN$(2): PRINT
2550 INPUT "YOUR NAME =?";IN$(3): PRINT
2560 INPUT "FILE NAME =?";IN$(4): PRINT
2570 INPUT "FILE DESCRIPTION =?";IN$(5): PRINT
2580 ID$ = IN$(4)
2590 REM
2600 REM      <<< WRITE RECORD GROUP 0 >>>
2610 REM
2620 RS%(0) = RI%: REM  RS% IS THE STARTING RECORD NO. FOR THE I TH GR
OUP.
2630 FOR I = 0 TO 5
2640 R% = I
2650 PRINT D$;"WRITE"ID$,"R"R%
2660 PRINT IN$(I)
2670 NEXT I
2680 PRINT D$
2690 RG%(0) = R% - RI%
2700 RI% = R%
2710 REM
2720 REM      <<< READ RECORD GROUP 0 >>>
2730 REM
2740 FOR I = 0 TO 5
2750 R% = I
2760 PRINT D$;"READ"ID$,"R"R%
2770 INPUT IN$(I)
2780 NEXT I
2790 PRINT D$

```

```

2800 REM
2810 REM <<< OUTPUT FOR RECORDGROUP 0 >>>
2820 REM
2830 ON PC% GOTO 2850,2832
2832 GOSUB 12955: REM PRINTER CODE 1
2840 REM
2850 PRINT : PRINT : PRINT "XXX RECORD GROUP 0 XXX": PRINT : PRINT
2860 PRINT "INFORMATION FOR FILENAME ";ID$: PRINT
2870 FOR I = 0 TO 5
2880 PRINT IN$(I)
2890 NEXT I
2895 GOSUB 12965: REM PRINTER CODE 2
2900 RETURN
2910 REM *****
2920 REM * SUB:RG1 *
2930 REM *****
2940 REM
2950 REM RECORD GROUP 1 CONTAINS THE STARTING RECORD NUMBER (RS%(I
)) AND NUMBER OF RECORDS FOR EACH GROUP RECORD (RG%(I))
2960 REM
2970 FL% = F1%(1)
2975 ON PT% GOTO 2980,3220,3050
2980 FOR I = 2 TO TG%
2990 RS%(I) = 0:RG%(I) = 0
3000 NEXT I
3010 RG%(1) = 4: REM THIS MUST BE CHANGED IF NO. OF RECORDS IN RG1 CH
ANGES.
3020 REM
3030 REM <<< WRITE RG1 >>>
3040 REM
3050 RS%(1) = RI% + 1
3060 R% = RS%(1)
3070 K = 1
3080 FOR I = 0 TO TG%
3090 B% = FL% * (K - 1)
3100 PRINT D$;"WRITE"ID$,"R"R%,"B"B%
3110 PRINT RS%(I): PRINT RG%(I)
3120 K = K + 1
3130 IF K > RL% / FL% THEN R% = R% + 1
3140 IF K > RL% / FL% THEN K = K - RL% / FL%
3150 NEXT I
3160 PRINT D$
3170 RG%(1) = R% - RI%
3180 RI% = R%
3190 REM
3200 REM <<< READ RG1 >>>
3210 REM
3220 RS%(1) = 6:R% = RS%(1):FL% = F1%(1)
3230 K = 1
3240 FOR I = 0 TO TG%
3250 B% = FL% * (K - 1)
3260 PRINT D$;"READ"ID$,"R"R%,"B"B%
3270 INPUT RS%(I): INPUT RG%(I)
3280 K = K + 1
3290 IF K > RL% / FL% THEN R% = R% + 1
3300 IF K > RL% / FL% THEN K = K - RL% / FL%
3310 NEXT I
3320 PRINT D$
3330 REM
3340 REM <<< OUTPUT RG1 >>>

```

```

3350 REM
3352 ON PC% GOTO 3360,3354
3354 GOSUB 12955: REM PRINTER CODE 1
3360 PRINT : PRINT : PRINT "XXX RECORD GROUP 1 ***": PRINT : PRINT
3370 PRINT "RECORD GROUP NUMBER, STARTING RECORD NUMBER, NUMBER OF RE
CORDS IN GROUP": PRINT
3390 FOR I = 0 TO TG% STEP 3
3400 FOR J = 0 TO 2
3410 K = 1 + (J * 20)
3415 IF PC% = 1 THEN K = 1 + (J * 10)
3420 L = I + J
3430 IF L > TG% GOTO 3480
3435 ON PC% GOTO 3444,3440
3440 POKE 36,K + 7: PRINT L;: POKE 36,K + 12: PRINT RS%(L);: POKE 36,
K + 17: PRINT RG%(L);
3443 GOTO 3450
3444 PRINT TAB( K );L; TAB( K + 3 );RS%(L); TAB( K + 6 );RG%(L);
3450 NEXT J
3460 PRINT
3470 NEXT I
3480 PRINT
3485 GOSUB 12965: REM PRINTER CODE 2
3490 RETURN
3500 REM *****
3510 REM * SUB: RG2 *
3520 REM *****
3530 REM
3540 REM RECORD GROUP 2 CONTAINS THE SELECTED CALCULATION OPTION N
UMBERS
3550 REM
3560 FL% = F1%(2)
3565 ON PT% GOTO 3590,4090,3590
3570 REM <<< INPUT: RG2 >>>
3580 REM
3590 PRINT
3600 PRINT "XXX CALCULATION OPTIONS ***": PRINT
3610 PRINT " 1 ALL OPTIONS": PRINT
3620 PRINT " 2 MUSLE ONLY ": PRINT
3630 PRINT " 3 LOADING FACTORS ONLY ": PRINT : PRINT
3870 INPUT "OPTION NUMBER =?";NO%(1): PRINT
3880 TC% = 1
3890 REM
3900 REM <<< WRITE RG2 >>>
3910 REM
3920 RS%(2) = RI% + 1: REM RS%(1) IS THE STARTING RECORD NUMBER FOR T
HE I TH GROUP
3930 R% = RS%(2)
3940 K = 1
3950 FOR I = 0 TO TC% - 1
3960 B% = FL% * (K - 1)
3970 PRINT D$;"WRITE"ID$,"R"R%,"B"B%
3980 PRINT NO%(I)
3990 K = K + 1
4000 IF K > RL% / FL% THEN R% = R% + 1
4010 IF K > RL% / FL% THEN K = K - RL% / FL%
4020 NEXT I
4030 PRINT D$
4040 RG%(2) = R% - RI%: REM RG%(1) = NO. OF RECORDS IN THE I TH GROU
P
4050 RI% = R%: REM RI% = RECORD INDEX NUMBER

```

```

4060 REM
4070 REM   <<< READ RG2 >>>
4080 REM
4090 R% = RS%(2):TC% = 5
4100 K = 1
4110 FOR I = 0 TO TC% - 1
4120 B% = FL% * (K - 1)
4130 PRINT D$;"READ"ID$,"R"R%,"B"B%
4140 INPUT NO%(I)
4150 K = K + 1
4160 IF K > RL% / FL% THEN R% = R% + 1
4170 IF K > RL% / FL% THEN K = K - RL% / FL%
4180 NEXT I
4190 PRINT D$
4200 REM
4210 REM   <<< OUTPUT RG2 >>>
4220 REM
4222 ON PC% GOTO 4230,4224
4224 GOSUB 12955: REM PRINTER CODE 1
4230 PRINT : PRINT : PRINT "XXX RECORD GROUP 2 XXX": PRINT : PRINT
4240 PRINT "CALCULATION OPTIONS": PRINT
4260 PRINT NO%(1)
4280 PRINT
4282 GOSUB 12965: REM PRINTER CODE 2
4290 RETURN
4300 REM *****
4310 REM * SUB: RG3 *
4320 REM *****
4330 REM
4340 REM RG3 CONTAINS THE LANDUSE AREAS OF THE SUB-WATERSHEDS
4350 NR% = NSUB%:NC% = NTYPE%:UN$ = "ACRES":TITLE$ = "LAND USE AREAS"
4360 NU% = NC%:FL% = FI%(3)
4370 ON PT% GOTO 4440,4720,4440
4380 REM
4390 REM   <<< INPUT RG3 >>>
4400 REM
4410 REM
4420 REM   <<<GOSUB:INPUT TO ARRAY>>>
4430 REM
4440 GOSUB 10240
4450 FOR I = 1 TO NR%
4460 FOR J = 1 TO NC%
4470 LAR(I,J) = AR(I,J)
4480 NEXT J
4490 NEXT I
4500 REM   <<< WRITE: RG3 >>>
4510 REM
4520 IF PT% = 3 THEN RI% = RS%(3) - 1
4530 RS%(3) = RI% + 1
4540 R% = RS%(3)
4550 K = 1
4560 FOR L = 1 TO NR%
4570 FOR J = 1 TO NC%
4580 B% = FL% * (K - 1)
4590 PRINT D$;"WRITE"ID$,"R"R%,"B"B%
4600 PRINT LAR(L,J)
4610 K = K + 1
4620 IF K > RL% / FL% THEN R% = R% + 1
4630 IF K > RL% / FL% THEN K = K - RL% / FL%
4640 NEXT J

```

```

4650 PRINT D$
4660 NEXT L
4670 RG%(3) = R% - RI%
4680 RI% = R%
4690 REM
4700 REM <<< READ: RG3 >>>
4710 REM
4720 R% = RS%(3):K = 1
4730 FOR L = 1 TO NR%
4740 FOR J = 1 TO NC%
4750 B% = FL% * (K - 1)
4760 PRINT D$;"READ"ID$,"R"R%,"B"B%
4770 INPUT LAR(L,J)
4780 K = K + 1
4790 IF K > RL% / FL% THEN R% = R% + 1
4800 IF K > RL% / FL% THEN K = K - RL% / FL%
4810 NEXT J
4820 PRINT D$
4830 NEXT L
4840 REM
4850 REM <<< OUTPUT: RG3 >>>
4860 REM
4862 IF PC% = 2 THEN GOSUB 12955
4870 HOME
4880 PRINT : PRINT : PRINT "XXXRECORD GROUP 3 XXX ": PRINT : PRINT
4890 HOME
4900 PRINT "LAND USE AREAS": PRINT
4901 ON PC% GOTO 4902,4914
4902 FOR L = 1 TO NR%: PRINT "SW ";L
4903 K1 = 1
4904 FOR J = 1 TO NC%
4905 PRINT TAB( K1);LAR(L,J);
4906 K1 = K1 + 6
4907 IF K1 < 40 GOTO 4910
4908 PRINT
4909 K1 = 1
4910 NEXT J
4911 PRINT
4912 NEXT L
4913 GOTO 4980
4914 FOR L = 1 TO NR%
4920 PRINT : PRINT "SW: ";L
4940 POKE 36,7: PRINT LAR(L,1);: POKE 36,13: PRINT LAR(L,2);: POKE 36
,19: PRINT LAR(L,3);: POKE 36,25: PRINT LAR(L,4);: POKE 36,31: PRINT L
AR(L,5);
4942 POKE 36,37: PRINT LAR(L,6);: POKE 36,43: PRINT LAR(L,7);: POKE 3
6,49: PRINT LAR(L,8);: POKE 36,55: PRINT LAR(L,9);
4944 POKE 36,61: PRINT LAR(L,10);: POKE 36,67: PRINT LAR(L,11);
4960 PRINT
4970 NEXT L
4975 GOSUB 12965: REM PRINTER CODE 2
4980 RETURN
4990 REM XXXXXXXXXXXXXXXXXXXXXXXX
5000 REM <<< SUB: RG4 >>>
5010 REM XXXXXXXXXXXXXXXXXXXXXXXX
5020 REM
5030 REM RG4 CONTAINS THE RAINFALL FACTOR R
5040 ON PT% GOTO 5080,5240,5080
5050 REM
5060 REM <<< INPUT: RG4 >>>

```

```

5070 REM
5080 HOME
5090 PRINT "   *** RAINFALL FACTOR ***": PRINT : PRINT
5100 INPUT "RAINFALL FACTOR=?";RF
5110 REM
5120 REM   <<< WRITE:RG4 >>>
5130 REM
5140 RS%(4) = RI% + 1:R% = RS%(4)
5150 B% = 0
5160 PRINT D$;"WRITE"ID$,"R"R%,"B"B%
5170 PRINT RF
5180 PRINT D$
5190 RG%(4) = R% - RI%
5200 RI% = R%
5210 REM
5220 REM   <<< READ:RG4 >>>
5230 REM
5240 R% = RS%(4)
5250 B% = 0
5260 PRINT D$;"READ"ID$,"R"R%,"B"B%
5270 INPUT RF
5280 PRINT D$
5290 REM
5300 REM   <<< OUTPUT:RG4>>>
5310 REM
5312 ON PC% GOTO 5320,5314
5314 GOSUB 12955: REM PRINTER CODE 1
5320 PRINT : PRINT : PRINT "*** RECORD GROUP 4 ***": PRINT : PRINT
5330 PRINT "RAINFALL FACTOR = ";RF: PRINT
5335 GOSUB 12965: REM PRINTER CODE 2
5340 RETURN
5350 REM *****
5360 REM   <<< SUB:RG5 >>>
5370 REM *****
5380 REM
5390 REM RG5 CONTAINS ERODIBILITY FACTORS FOR FOREST AND AGRICULTURA
L LAND USE
5400 NR% = NSUB%:NC% = NTYPE%:UN$ = "TONS/ACRE/R UNIT ":TITLE$ = "SOIL
ERODIBILITY FACTOR":NU% = 6:FL% = F1%(5)
5410 ON PT% GOTO 5450,5710,5720
5420 REM
5430 REM   <<< INPUT: RG5 >>>
5440 REM
5450 GOSUB 10240
5460 FOR I = 1 TO NR%
5470 FOR J = 1 TO NU%
5480 KF(I,J) = AR(I,J)
5490 NEXT J
5500 NEXT I
5510 REM   <<< WRITE: RG5 >>>
5520 REM
5530 RS%(5) = RI% + 1:R% = RS%(5)
5540 K = 1:NF% = RL% / FL%
5550 FOR I = 1 TO NR%
5560 FOR J = 1 TO NU%
5570 B% = FL% * (K - 1)
5580 PRINT D$;"WRITE"ID$,"R"R%,"B"B%
5590 PRINT KF(I,J)
5600 K = K + 1
5610 IF K > NF% THEN R% = R% + 1

```

```

5620 IF K > NF% THEN K = K - NF%
5630 NEXT J
5640 PRINT D$
5650 NEXT I
5660 RG%(5) = R% - RI%
5670 RI% = R%
5680 REM
5690 REM <<< READ:RG5 >>>
5700 REM
5710 R% = RS%(5):K = 1:NF% = RL% / FL%
5720 FOR I = 1 TO NR%
5730 FOR J = 1 TO NU%
5740 B% = FL% * (K - 1)
5750 PRINT D$;"READ"ID$,"R"R%,"B"B%
5760 INPUT KF(I,J)
5770 K = K + 1
5780 IF K > NF% THEN R% = R% + 1
5790 IF K > NF% THEN K = K - NF%
5800 NEXT J
5810 PRINT D$
5820 NEXT I
5830 REM
5840 REM <<< OUTPUT: RG5 >>>
5850 REM
5852 ON PC% GOTO 5860,5854
5854 GOSUB 12955: REM PRINTER CODE 1
5860 PRINT : PRINT : PRINT "XXX RECORD GROUP 5 ***": PRINT : PRINT
5870 PRINT "ERODIBILITY FACTOR": PRINT
5880 PRINT
5890 FOR I = 1 TO NR%
5900 PRINT "SW ";I;" ";
5910 FOR J = 1 TO NU%
5920 PRINT KF(I,J);" ";
5930 NEXT J
5940 PRINT
5950 NEXT I
5955 GOSUB 12965: REM PRINTER CODE 2
5960 RETURN
5970 REM *****
5980 REM <<< SUB:RG6 >>>
5990 REM *****
6000 REM RG6 CONTAINS LENGTH FACTORS FOR FOREST AND AGRICULTURAL LAN
D USES
6010 REM
6020 NR% = NSUB%:NC% = NTYPE%:UN$ = "NONE ":TITLE$ = " LENGTH FACTOR "

6030 NU% = 6:NF% = RL% / FL%
6040 ON PT% GOTO 6080,6350,6080
6050 REM
6060 REM <<< INPUT: RG6 >>>
6070 REM
6080 GOSUB 10240
6090 FOR I = 1 TO NR%
6100 FOR J = 1 TO NU%
6110 LF(I,J) = AR(I,J)
6120 NEXT J
6130 NEXT I
6140 REM
6150 REM <<< WRITE: RG6 >>>
6160 REM

```



```

6170 RS%(6) = RI% + 1:R% = RS%(6)
6180 K = 1
6190 FOR I = 1 TO NR%
6200 FOR J = 1 TO NU%
6210 B% = FL% * (K - 1)
6220 PRINT D$;"WRITE"ID$,"R"R%,"B"B%
6230 PRINT LF(I,J)
6240 K = K + 1
6250 IF K > NF% THEN R% = R% + 1
6260 IF K > NF% THEN K = K - NF%
6270 NEXT J
6280 PRINT D$
6290 NEXT I
6300 RG%(6) = R% - RI%
6310 RI% = R%
6320 REM
6330 REM <<<READ: RG6 >>>
6340 REM
6350 R% = RS%(6):K = 1
6360 FOR I = 1 TO NR%
6370 FOR J = 1 TO NU%
6380 B% = FL% * (K - 1)
6390 PRINT D$;"READ"ID$,"R"R%,"B"B%
6400 INPUT LF(I,J)
6410 K = K + 1
6420 IF K > NF% THEN R% = R% + 1
6430 IF K > NF% THEN K = K - NF%
6440 NEXT J
6450 PRINT D$
6460 NEXT I
6470 REM
6480 REM <<< OUTPUT: RG6 >>>
6490 REM
6492 ON PC% GOTO 6500,6494
6494 GOSUB 12955: REM PRINTER CODE 1
6500 PRINT : PRINT : PRINT "XXX RECORD GROUP 6 XXX": PRINT : PRINT
6510 PRINT "LENGTH FACTOR": PRINT
6520 FOR I = 1 TO NR%
6530 PRINT "SW ";I;" ";
6540 FOR J = 1 TO NU%
6550 PRINT LF(I,J);" ";
6560 NEXT J
6570 PRINT
6580 NEXT I
6590 PRINT
6595 GOSUB 12965: REM PRINTER CODE 2
6600 RETURN
6610 REM *****
6620 REM <<< SUB: RG7 >>>
6630 REM *****
6640 REM RG7 CONTAINS SLOPE FACTORS FOR FOREST AND AGRICULTURAL LAND
    USE
6650 REM
6660 NR% = NSUB%:NC% = NTYPE%:UN$ = "NONE":TITLE$ = "SLOPE FACTOR"
6670 NU% = 6:FL% = F1%(7):NF% = RL% / FL%
6680 ON PT% GOTO 6720,6890,6890
6690 REM
6700 REM <<< INPUT: RG7 >>>
6710 REM
6720 GOSUB 10240

```

```

6730 FOR I = 1 TO NR%
6740 FOR J = 1 TO NU%
6750 SF(I,J) = AR(I,J)
6760 NEXT J
6770 NEXT I
6780 REM <<< WRITE: RG7 >>>
6790 REM
6800 RS%(7) = RI% + 1
6810 R% = RS%(7)
6820 K = 1
6830 GOSUB 10400
6840 RG%(7) = R% - RI%
6850 RI% = R%
6860 REM
6870 REM <<< READ: RG7 >>>
6880 REM
6890 R% = RS%(7):K = 1
6900 GOSUB 10610
6910 FOR I = 1 TO NR%
6920 FOR J = 1 TO NU%
6930 SF(I,J) = AR(I,J)
6940 NEXT J
6950 NEXT I
6960 REM
6970 REM <<< OUTPUT:RG7 >>>
6980 REM
6990 G% = 7:TITLE$ = "SLOPE FACTOR":NU% = 6
7000 GOSUB 10770
7010 RETURN
7020 REM *****
7030 REM <<< SUB: RG8 >>>
7040 REM *****
7050 REM RG8 CONTAINS COVER FACTOR FOR FOREST AND AGRICULTURAL LAND
    USE
7060 REM
7070 NR% = NSUB%:NC% = NTYPE%:UN$ = "NONE":TITLE$ = "COVER FACTOR "
7080 NU% = 6:FL% = F1%(8):NF% = RL% / FL%
7090 ON PT% GOTO 7130,7320,7130
7100 REM
7110 REM <<< INPUT: RG8 >>>
7120 REM
7130 GOSUB 10240
7140 FOR I = 1 TO NR%
7150 FOR J = 1 TO NU%
7160 CF(I,J) = AR(I,J)
7170 NEXT J
7180 NEXT I
7190 REM
7200 REM <<< WRITE: RG8 >>>
7210 REM
7220 RS%(8) = RI% + 1
7230 R% = RS%(8)
7240 K = 1
7260 GOSUB 10400
7270 RG%(8) = R% - RI%
7280 RI% = R%
7290 REM
7300 REM <<< READ: RG8 >>>
7310 REM
7320 R% = RS%(8):K = 1

```

```

7330 K = 1:NU% = 6:NF% = RL% / FL%
7340 GOSUB 10610
7350 FOR I = 1 TO NR%
7360 FOR J = 1 TO NU%
7370 CF(I,J) = AR(I,J)
7380 NEXT J
7390 NEXT I
7400 MF% = 1
7410 REM
7420 REM <<< OUTPUT: RG8 >>>
7430 REM
7440 G% = 8:TITLE$ = "COVER FACTOR":NU% = 6
7450 GOSUB 10770
7460 RETURN
7470 REM *****
7480 REM <<< SUB: RG9 >>>
7490 REM *****
7500 REM
7510 REM RG9 CONTAINS PRACTICES FACTOR FOR FOREST AND AGRICULTURAL L
AND USE
7520 REM
7530 NR% = NSUB%:NC% = NTYPE%:UN$ = "NONE":TITLE$ = "PRACTICES FACTOR
"
7540 NU% = 6:FL% = F1%(9):NF% = RL% / FL%
7550 ON PT% GOTO 7590,7770,7590
7560 REM
7570 REM <<< INPUT: RG9 >>>
7580 REM
7590 GOSUB 10240
7600 FOR I = 1 TO NR%
7610 FOR J = 1 TO NU%
7620 PF(I,J) = AR(I,J)
7630 NEXT J
7640 NEXT I
7650 REM
7660 REM <<< WRITE: RG9 >>>
7670 REM
7680 RS%(9) = RI% + 1
7690 R% = RS%(9)
7700 K = 1
7710 GOSUB 10400
7720 RG%(9) = R% - RI%
7730 RI% = R%
7740 REM
7750 REM <<< READ:R82-R96 >>>
7760 REM
7770 R% = RS%(9):K = 1
7780 GOSUB 10610
7790 FOR I = 1 TO NR%
7800 FOR J = 1 TO NU%
7810 PF(I,J) = AR(I,J)
7820 NEXT J
7830 NEXT I
7840 REM
7850 REM <<< OUTPUT: RG9 >>>
7860 REM
7870 G% = 9:TITLE$ = "PRACTICES FACTOR":NU% = 6
7880 GOSUB 10770
7890 RETURN
7900 REM *****

```

```

7910 REM    <<< SUB: RG10 >>>
7920 REM    *****
7930 REM    RG10 CONTAINS SEDIMENT DELIVERY RATIOS FOR FOREST AND AGRIC
ULTRAL LAND USE
7940 REM
7950 NR% = NSUB%:NC% = NTYPE%:UN$ = "NONE":TITLE$ = "SEDIMENT DELIVERY
RATIO"
7960 NU% = 6:FL% = F1%(10):NF% = RL% / FL%
7970 ON PT% GOTO 8010,8170,8010
7980 REM
7990 REM    <<< INPUT: RG10 >>>
8000 REM
8010 GOSUB 10240
8020 FOR I = 1 TO NR%
8030 FOR J = 1 TO NU%
8040 SD(I,J) = AR(I,J)
8050 NEXT J
8060 NEXT I
8070 REM
8080 REM    <<< WRITE: RG10 >>>
8090 REM
8100 RS%(10) = RI% + 1
8110 R% = RS%(10)
8120 K = 1
8130 GOSUB 10400
8140 RG%(10) = R% - RI%
8150 RI% = R%
8160 REM
8170 REM    <<< READ: RG10 >>>
8180 REM
8190 R% = RS%(10):K = 1
8200 GOSUB 10610
8210 FOR I = 1 TO NR%
8220 FOR J = 1 TO NU%
8230 SD(I,J) = AR(I,J)
8240 NEXT J
8250 NEXT I
8260 REM
8270 REM    <<< OUTPUT: RG10 >>>
8280 REM
8290 G% = 10:TITLE$ = "SEDIMENT DELIVERY RATIO"
8300 GOSUB 10770
8310 RETURN
8320 REM    *****
8330 REM    <<< SUB: RG11 >>>
8340 REM    *****
8350 REM
8360 REM    RG11 CONTAINS CONSTANTS FOR NITROGEN CALCULATION
8370 REM
8380 FL% = F1%(11):NF% = RL% / FL%
8390 ON PT% GOTO 8420,8710,8420
8400 REM
8410 REM    <<< INPUT: RG11 >>>
8420 HOME
8430 PRINT "*** NITROGEN PARAMETERS ***": PRINT : PRINT
8440 INPUT "TOTAL NITROGEN CONCENTRATION IN SOIL (G/100 G) = ?";RC(1)

8450 INPUT "ENRICHMENT RATIO = ?";RC(2)
8460 INPUT "OVERLAND FLOW FROM RAIN (IN/YEAR) = ?";RC(3)
8470 INPUT "NITROGEN LOAD IN RAIN (LB/ACRE/YEAR) = ?";RC(4)

```

```

8480 INPUT "TOTAL RAIN = ?";RC(5)
8490 INPUT "(AVAILABLE/TOTAL) NITROGEN IN SEDIMENT = ?";RC(6)
8500 RC(7) = 0
8510 REM
8520 REM <<< WRITE: RG11 >>>
8530 REM
8540 RS%(11) = RI% + 1
8550 R% = RS%(11):K = 1
8560 K = 1:NF% = RL% / FL%:NU% = 6
8570 FOR J = 1 TO NU%
8580 B% = FL% * (K - 1)
8590 PRINT D$;"WRITE"ID$,"R"R%,"B"B%
8600 PRINT RC(J)
8610 K = K + 1
8620 IF K > NF% THEN R% = R% + 1
8630 IF K > NF% THEN K = K - NF%
8640 NEXT J
8650 PRINT D$
8660 RG%(11) = R% - RI%
8670 RI% = R%
8680 REM
8690 REM <<< READ: RG11 >>>
8700 REM
8710 R% = RS%(11):K = 1
8720 FOR J = 1 TO NU%
8730 B% = FL% * (K - 1)
8740 PRINT D$;"READ"ID$,"R"R%,"B"B%
8750 INPUT RC(J)
8760 K = K + 1
8770 IF K > NF% THEN R% = R% + 1
8780 IF K > NF% THEN K = K - NF%
8790 NEXT J
8800 CNT = RC(1):RN = RC(2):OLF = RC(3):N1 = RC(4):RAIN = RC(5):F1 = R
C(6)
8810 PRINT D$
8820 REM
8830 REM <<< OUTPUT: RG11 >>>
8840 REM
8842 ON PC% GOTO 8850,8846
8846 GOSUB 12955: REM PRINTER CODE 1
8850 PRINT : PRINT : PRINT "XXX RECORD GROUP 11 XXX": PRINT : PRINT
8860 PRINT " NITROGEN PARAMETERS": PRINT
8870 PRINT "TOTAL NITROGEN CONCENTRATION IN SOIL =";CNT;" (G/100 G)"

8880 PRINT "ENRICHMENT RATIO =";RN
8890 PRINT "OVERLAND FLOW FROM RAIN =";OLF;"(IN/YEAR)2"
8900 PRINT "NITROGEN LOAD IN RAIN =";N1;" (LB/ACRE/YEAR)"
8910 PRINT "TOTAL RAIN = ";RAIN;" (IN/YEAR)"
8920 PRINT "(AVAILABLE/TOTAL) NITROGEN IN SEDIMENT =";F1
8925 GOSUB 12965: REM PRINTER CODE 2
8930 RETURN
8940 REM *****
8950 REM <<< SUB: RG12 >>>
8960 REM *****
8970 REM
8980 REM RG12 CONTAINS CONTENTS FOR PHOSPHOROUS CALCULATIONS
8990 REM
9000 FL% = F1%(12):NF% = RL% / FL%
9010 ON PT% GOTO 9020,9260,9020
9020 HOME

```

```

9030 PRINT "XXX PHOSPHOROUS PARAMETERS XXX"; PRINT : PRINT
9040 INPUT "TOTAL PHOSPHOROUS CONCENTRATION IN SOIL (G/100G) =?"; PC(1)
9050 INPUT "PHOSPHOROUS ENRICHMENT RATIO = ?"; PC(2); PRINT
9060 INPUT " (AVAILABLE/TOTAL) PHOSPHOROUS IN SOIL = ?"; PC(3); PRINT

9070 REM
9080 REM <<< WRITE: RG12 >>>
9090 REM
9100 RS%(12) = RI% + 1
9110 R% = RS%(12); K = 1
9120 FOR J = 1 TO 3
9130 B% = FL% * (K - 1)
9140 PRINT D$; "WRITE" ID$, R"R%", B"B%
9150 PRINT PC(J)
9160 K = K + 1
9170 IF K > NF% THEN R% = R% + 1
9180 IF K > NF% THEN K = K - NF%
9190 NEXT J
9200 PRINT D$
9210 RG%(12) = R% - RI%
9220 RI% = R%
9230 REM
9240 REM <<< READ: RG12 >>>
9250 REM
9260 R% = RS%(12); K = 1
9270 FOR J = 1 TO 3
9280 B% = FL% * (K - 1)
9290 PRINT D$; "READ" ID$, R"R%", B"B%
9300 INPUT PC(J)
9310 K = K + 1
9320 IF K > NF% THEN R% = R% + 1
9330 IF K > NF% THEN K = K - NF%
9340 NEXT J
9350 PRINT D$
9360 REM
9370 REM <<< OUTPUT: RG12 >>>
9380 REM
9382 ON PC% GOTO 9390, 9384
9384 GOSUB 12955: REM PRINTER CODE 1
9390 PRINT : PRINT : PRINT "XXX RECORD GROUP 12 XXX"; PRINT : PRINT
9400 PRINT "PHOSPHOROUS PARAMETERS": PRINT
9410 PRINT "TOTAL PHOSPHOROUS CONCENTRATION IN SOIL = "; PC(1); " G/100
G ";
9420 PRINT "PHOSPHOROUS ENRICHMENT RATIO = "; PC(2)
9430 PRINT "(AVAILABLE/TOTAL) PHOSPHOROUS IN SOIL = "; PC(3)
9440 PRINT
9445 GOSUB 12965: REM PRINTER CODE 2
9450 RETURN
9460 REM *****
9470 REM * SUB: RG13 *
9480 REM *****
9490 REM
9500 REM RG13 CONTAINS CONSTANTS FOR ORGANIC MATTER CALCULATIONS
9510 REM
9520 FL% = F1%(13); NF% = RL% / FL%
9530 ON PT% GOTO 9540, 9770, 9540
9540 HOME
9550 PRINT "XXX ORGANIC MATTER PARAMETERS XXX": PRINT : PRINT
9560 INPUT "ORGANIC MATTER CONCENTRATION OF SOIL (G/100G) =?"; OM(1);

```

```

9570 INPUT "ORGANIC MATTER ENRICHMENT RATIO = ?";OM(2)
9580 REM
9590 REM    <<< WRITE: RG13 >>>
9600 REM
9610 RS%(13) = RI% + 1
9620 R% = RS%(13);K = 1
9630 FOR J = 1 TO 2
9640 B% = FL% * (K - 1)
9650 PRINT D$;"WRITE"ID$,"R"R%,"B"B%
9660 PRINT OM(J)
9670 K = K + 1
9680 IF K > NF% THEN R% = R% + 1
9690 IF K > NF% THEN K = K - NF%
9700 NEXT J
9710 PRINT D$
9720 RG%(13) = R% - RI%
9730 RI% = R%
9740 REM
9750 REM    <<< READ : RG13 >>>
9760 REM
9770 R% = RS%(13);K = 1
9780 FOR J = 1 TO 2
9790 B% = FL% * (K - 1)
9800 PRINT D$;"READ"ID$,"R"R%,"B"B%
9810 INPUT OM(J)
9820 K = K + 1
9830 IF K > NF% THEN R% = R% + 1
9840 IF K > NF% THEN K = K - NF%
9850 NEXT J
9860 PRINT D$
9870 REM
9880 REM    <<< OUTPUT: RG13 >>>
9890 REM
9892 ON PC% GOTO 9900,9894
9894 GOSUB 12955: REM PRINTER CODE 1
9900 PRINT : PRINT : PRINT "XXX RECORD GROUP 13 XXX": PRINT : PRINT
9910 PRINT "ORGANIC MATTER PARAMETERS": PRINT
9920 PRINT "ORGANIC MATTER CONCENTRATION OF SOIL = ";OM(1)
9930 PRINT "ORGANIC MATTER ENRICHMENT RATIO = ";OM(2)
9940 PRINT
9945 GOSUB 12965: REM PRINTER CODE 2
9950 RETURN
9960 REM *****
9970 REM * SUB:RG14 *
9980 REM *****
9990 REM
10000 REM RG14 CONTAINS LOADING FACTORS
10010 REM
10020 FL% = F1%(14):NF% = RL% / FL%
10030 ON PT% GOTO 10070,10150,10070
10040 REM
10050 REM    <<< INPUT: RG14 >>>
10060 REM
10070 GOSUB 11430
10080 REM
10090 REM    <<< WRITE: RG14 >>>
10100 REM
10110 GOSUB 11810
10120 REM
10130 REM    <<< READ: RG14 >>>

```

```

10140 REM
10150 GOSUB 12000
10160 REM
10170 REM    <<< OUTPUT: RG14 >>>
10180 REM
10190 GOSUB 12160
10200 RETURN
10210 REM *****
10220 REM    <<< SUB:INPUT TO ARRAY >>>
10230 REM *****
10240 PRINT : PRINT
10250 PRINT "    ** INPUT:SUB-WATERSHED **": PRINT
10260 PRINT TITLE$: PRINT
10270 PRINT "INPUT IN UNITS OF ";UN$: PRINT : PRINT
10280 FOR I = 1 TO NR%
10290 PRINT "SUB-WATERSHED ";I;"    **": PRINT
10300 FOR J = 1 TO NC%
10310 PRINT SW$(J);" = ";
10320 INPUT AR(I,J)
10330 IF J = NU% GOTO 10350
10340 NEXT J
10345 PRINT
10350 NEXT I
10360 RETURN
10370 REM *****
10380 REM    <<< SUB:WRITE RECORDS>>>
10390 REM *****
10400 FOR I = 1 TO NR%
10410 FOR J = 1 TO NC%
10420 B% = FL% * (K - 1)
10430 PRINT D$;"WRITE"ID$,"R"R$,"B"B%
10450 PRINT AR(I,J)
10490 K = K + 1
10500 IF K > NF% THEN R% = R% + 1
10510 IF K > NF% THEN K = K - NF%
10520 IF J = NU% THEN GOTO 10540
10530 NEXT J
10540 PRINT D$
10550 NEXT I
10560 MF% = 1
10570 RETURN
10580 REM *****
10590 REM    <<< SUB:READ RECORDS >>>
10600 REM *****
10610 FOR I = 1 TO NR%
10620 FOR J = 1 TO NC%
10630 B% = FL% * (K - 1)
10640 PRINT D$;"READ"ID$,"R"R$,"B"B%
10650 INPUT AR(I,J)
10660 K = K + 1
10670 IF K > RL% / FL% THEN R% = R% + 1
10680 IF K > RL% / FL% THEN K = K - RL% / FL%
10690 IF J = NU% GOTO 10710
10700 NEXT J
10710 PRINT D$
10720 NEXT I
10730 RETURN
10740 REM *****
10750 REM    <<< SUB: OUTPUT RECORDS>>>
10760 REM *****

```



```

10770 IF PC% = 2 THEN GOSUB 12955: REM PRINTER CODE
10778 PRINT : PRINT : PRINT "XXX RECORD GROUP ";G%;" XXX": PRINT
: PRINT
10779 PRINT TITLE$: PRINT
10780 ON PC% GOTO 10782,10794
10782 FOR I = 1 TO NC%: PRINT "SW ";I
10783 K1 = 1
10784 FOR J = 1 TO NC%
10785 PRINT TAB( K1);AR(I,J);
10786 IF J = NU% GOTO 10790
10787 K1 = K1 + 6
10788 IF K1 > 40 THEN K1 = 1
10789 NEXT J
10790 PRINT
10791 NEXT I
10792 PRINT
10793 GOTO 10880
10794 FOR I = 1 TO NR%
10800 PRINT "SW ";I
10820 POKE 36,7: PRINT AR(I,1);: POKE 36,13: PRINT AR(I,2);: POKE 36,
19: PRINT AR(I,3);: POKE 36,25: PRINT AR(I,4);: POKE 36,31: PRINT AR(I
,5);: POKE 36,37: PRINT AR(I,6);
10821 IF NU% = 6 GOTO 10850
10822 POKE 36,43: PRINT AR(I,7);: POKE 36,49: PRINT AR(I,8);: POKE 36
,55: PRINT AR(I,9);
10824 POKE 36,61: PRINT AR(I,10);: POKE 36,67: PRINT AR(I,11);
10850 PRINT
10860 NEXT I
10870 PRINT
10875 GOSUB 12965: REM PRINTER CODE 2
10880 RETURN
10890 REM *****
10900 REM * SUB: CHANGE PARAMETERS *
10910 REM *****
10920 REM DISPLAY EDITING CHOICES
10930 HOME
10940 PRINT "XXX PARAMETER GROUPS XXX": PRINT : PRINT
10950 PRINT " 0 FILE DESCRIPTION "
10960 PRINT " 1 CALCULATION OPTIONS"
10970 PRINT " 2 LAND USE AREAS"
10980 PRINT " 3 RAINFALL FACTORS"
10990 PRINT " 4 ERODIBILITY FACTORS"
11000 PRINT " 5 LENGTH FACTORS"
11010 PRINT " 6 SLOPE FACTORS"
11020 PRINT " 7 COVER FACTORS"
11030 PRINT " 8 PRACTICES FACTORS"
11040 PRINT " 9 SEDIMENT DELIVERY RATIOS"
11050 PRINT " 10 NITROGEN PARAMETERS"
11060 PRINT " 11 PHOSPHOROUS PARAMETERS"
11070 PRINT " 12 ORGANIC PARAMETERS "
11080 PRINT " 13 LOADING FACTORS"
11090 PRINT
11100 INPUT "CHANGE NUMBER = ?";CN%
11110 CN% = CN% + 1
11120 REM
11130 REM <<< GOSUB:CHOOSE DAT ARRAY CHANGE METHOD >>>
11140 REM
11150 GOSUB 11320
11160 REM LOAD APPROPRIATE VALUES FOR RECORD INDEX RI%
11170 IF AC% = 1 GOTO 11240

```

```

11180 RI% = RS%(CN%) - 1
11190 REM
11200 ON CN% GOSUB 2440,3590,4350,5080,5400,6020,6660,7070,7530,7950,
8390,9010,9530,10020
11210 PRINT "DO YOU WANT TO CHANGE ANOTHER SET OF PARAMETERS ? ( Y OR
N )": PRINT
11220 INPUT A$
11230 IF A$ = "Y" GOTO 10930
11235 GOTO 11380
11240 GOSUB 12300: REM CHANGE SINGLE ELEMENT
11280 RETURN
11290 REM *****
11300 REM * SUB: CHOOSE DATA RRAY CHANGE METHOD *
11310 REM *****
11320 IF CN% < 3 OR CN% = 4 GOTO 11380
11330 IF CN% > = 11 AND CN% < = 13 GOTO 11380
11340 PRINT "OPTIONS:"
11350 PRINT " 1 CHANGE SINGLE ELEMENT IN ARRAY"
11360 PRINT " 2 CHANGE ENTIRE DATA ARRAY": PRINT
11370 INPUT "OPTION NUMBER = ?":AC%
11380 RETURN
11390 REM *****
11400 REM * SUB: RG14 INPUT *
11410 REM *****
11420 REM
11430 HOME
11440 PRINT "XXX LOADING FACTORS XXX": PRINT : PRINT
11450 PRINT "OPTIONS:"
11460 PRINT " 1 AUTOMATIC LOADING OF STORED VALUES "
11470 PRINT " 2 DIRECT INPUT FROM KEYBOARD ": PRINT
11480 INPUT "OPTION NUMBER = ?":A%
11490 IF A% = 2 GOTO 11680
11500 REM
11510 REM AUTOMATICALLY READ DATA AND STORE IN ARRAY HF(I,J)
11520 REM
11530 DATA 1,2,3,4,5,6,7,8,9,10,11
11540 DATA 12,13,14,15,16,17,18,19,20,21,22
11550 DATA 23,24,25,26,27,28,29,30,31,32,33
11560 DATA 34,35,36,37,38,39,40,41,42,43,44
11570 DATA 45,46,47,48,49,50,51,52,53,54,55
11580 DATA 56,57,58,59,60,61,62,63,64,65,66
11590 FOR I = 1 TO 6
11600 FOR J = 1 TO 11
11610 READ HF(I,J)
11620 NEXT J
11630 NEXT I
11640 GOTO 11770
11650 REM
11660 REM DIRECT INPUT FROM KEYBOARD
11670 REM
11680 PRINT "INPUT LOADING FACTORS USING UNITS OF LBS/ACRE/YEAR": PRI
NT
11690 REM
11700 FOR I = 1 TO 6
11710 PRINT LF$(I)
11720 FOR J = 1 TO 11
11730 PRINT " ";SW$(J);" = ";
11740 INPUT HF(I,J)
11750 NEXT J
11760 NEXT I

```

```

11770 RETURN
11780 REM *****
11790 REM * SUB:RG14 WRITE *
11800 REM *****
11810 RS%(14) = RI% + 1
11820 R% = RS%(14):K = 1
11830 FOR I = 1 TO 6
11840 FOR J = 1 TO 11
11850 B% = FL% * (K - 1)
11860 PRINT D$;"WRITE"ID$,"R"R%,"B"B%
11870 PRINT HF(I,J)
11880 K = K + 1
11890 IF K > NF% THEN R% = R% + 1
11900 IF K > NF% THEN K = K - NF%
11910 NEXT J
11920 PRINT D$
11930 NEXT I
11940 RG%(14) = R% - RI%
11950 RI% = R%
11960 RETURN
11970 REM *****
11980 REM * SUB:RG14 READ *
11990 REM *****
12000 R% = RS%(14):K = 1
12010 FOR I = 1 TO 6
12020 FOR J = 1 TO 11
12030 B% = FL% * (K - 1)
12040 PRINT D$;"READ"ID$,"R"R%,"B"B%
12050 INPUT HF(I,J)
12060 K = K + 1
12070 IF K > NF% THEN R% = R% + 1
12080 IF K > NF% THEN K = K - NF%
12090 NEXT J
12100 PRINT D$
12110 NEXT I
12120 RETURN
12130 REM *****
12140 REM * SUB:RG14 OUTPUT *
12150 REM *****
12160 ON PC% GOTO 12168,12162
12162 GOSUB 12955: REM PRINTER CODE 1
12168 PRINT : PRINT : PRINT "XXXRECORD GROUP 14 ***": PRINT
12170 PRINT " LOADING FACTORS ": PRINT
12180 FOR I = 1 TO 6
12190 PRINT LF$(I)
12200 FOR J = 1 TO 11
12210 PRINT HF(I,J);" ";
12220 NEXT J
12230 PRINT
12240 NEXT I
12250 PRINT
12255 GOSUB 12965: REM PRINTER CODE '2
12260 RETURN
12270 REM *****
12280 REM * SUB: CHNAGE SINGLE ELEMENT IN DATA ARRAY *
12290 REM *****
12300 RI% = RS%(CN%)
12310 PRINT "RECORD GROUP NUMBER ";CN%: PRINT
12320 PRINT "CHANGE ELEMENT (I,J) IN DATA ARRAY": PRINT
12330 INPUT "ROW NUMBER = ?";II

```

```

12340 INPUT "COLUMN NUMBER = ?";JJ
12350 REM
12360 REM      CONVERT (I,J) TO RECORD (R%) AND FIELD (B%) VALUES
12370 REM
12380 REM  FIND CORRECT VALUES FOR NUMBER OF COLUMNS IN PARTICULAR AR
RAY
12390 REM
12400 CO% = 6
12403 IF CN% = 3 OR CN% = 14 THEN CO% = 11
12410 LN% = CO% * (II - 1) + JJ
12420 FL% = F1%(CN%)
12422 NF% = RL% / FL%
12440 RN = LN% / NF%;RN = RN - .01
12450 R% = INT (RN) + RS%(CN%)
12455 AN = RN + .01 - INT (RN)
12456 BN = AN * RL%;CN = BN + .001 - FL%
12460 B% = CN
12466 BN = AN * RL%
12480 REM  READ AND PRINT CURRENT VALUE
12490 PRINT D$;"READ"ID$,"R"R%,"B"B%
12500 INPUT AA
12510 PRINT D$
12520 PRINT "CURRENT VALUE OF ELEMENT (";II;",";JJ;) = ";AA
12530 PRINT
12540 INPUT "NEW VALUE OF ELEMENT = ?";BB
12550 PRINT D$;"WRITE"ID$,"R"R%,"B"B%
12560 PRINT BB
12570 PRINT D$
12580 INPUT "DO YOU WANT TO CHANGE ANOTHER ELEMENT IN THE SAME ARRAY
? (Y OR N)";A$
12590 IF A$ = "Y" GOTO 12320
12600 RETURN
12950 REM *****
12951 REM *      SUB: PRINTER CODE 1 *
12952 REM *****
12955 PRINT D$;"PR#1": PRINT I$;"7L": PRINT I$;"80N"
12958 RETURN
12960 REM *****
12962 REM *      SUB: PRINTER CODE 2 *
12963 REM *****
12965 PRINT D$;"PR#0"
12968 RETURN

```

1LIST

```

20000 REM *****
20010 REM <<< SUB:SOIL >>>
20020 REM *****
20030 REM
20040 REM GO SUB:TABLE(SW AREAS)
20050 REM
20070 GOSUB 21260
20080 REM
20090 U1$ = "TONS/YEAR"
20100 REM
20110 REM <<< UNIVERSAL SOIL LOSS EQUATION >>>
20120 REM
20130 NU% = 6
20140 FOR I = 1 TO NR%
20150 FOR J = 1 TO NU%
20160 SL(I,J) = RF * KF(I,J) * LF(I,J) * SF(I,J) * CF(I,J) * PF(I,J)
20170 SL(I,J) = SL(I,J) * LAR(I,J)
20180 NEXT J
20190 NEXT I
20200 REM
20210 REM <<< GO SUB:TABLE(SOIL LOSS) >>>
20220 REM
20230 GOSUB 21540
20240 REM
20250 REM <<< DELIVERED SOIL >>>
20260 REM
20270 FOR I = 1 TO NR%
20280 FOR J = 1 TO NU%
20290 DD(I,J) = SL(I,J) * SD(I,J)
20300 NEXT J
20310 NEXT I
20320 REM
20330 REM <<< GO SUB:TABLE(DELIVERED SOIL) >>>
20340 REM
20350 GOSUB 21690
20360 REM
20370 REM <<< GO SUB:LAND USE >>>
20380 REM
20390 GOSUB 22410
20400 REM
20410 REM <<< SUB-WATERSHED SOIL LOSS >>>
20420 REM
20430 REM
20440 REM <<< TONS/YEAR >>>
20450 REM
20460 FOR I = 1 TO NR%
20470 A1 = 0
20480 FOR J = 1 TO NU%
20490 A1 = A1 + SL(I,J)
20500 NEXT J
20510 SQ(I) = A1
20520 NEXT I
20530 REM
20540 REM <<< GO SUB:TABLE(SW SOIL LOSS) >>>
20550 REM

```

```

20560 GOSUB 22010
20570 REM
20580 REM <<<SUB-WATERSHED DELIVERED SOIL >>>
20590 REM
20600 REM
20610 REM <<< TONS/YEAR >>>
20620 REM
20630 FOR I = 1 TO NR%
20640 A1 = 0
20650 FOR J = 1 TO NU%
20660 A1 = A1 + DD(I,J)
20670 NEXT J
20680 DQ(I) = A1
20690 NEXT I
20700 REM
20710 REM <<< GO SUB:TABLE(SW DELIVERED SOIL) >>>
20720 REM
20730 GOSUB 22150
20740 REM
20750 REM <<< TOTAL SOIL LOSS >>>
20760 REM
20770 REM
20780 REM <<< TONS/YEAR >>>
20790 REM
20800 TD = 0
20810 FOR I = 1 TO NR%
20820 TD = TD + SQ(I)
20830 NEXT I
20840 PRINT "TOTAL SOIL LOSS": PRINT
20845 TD = INT (10 * TD + .5) / 10
20850 POKE 36,11: PRINT TD;" TONS/YEAR": PRINT
20860 REM
20870 REM <<< TOTAL DELIVERED SOIL >>>
20880 REM
20890 REM <<< TONS/YEAR >>>
20900 REM
20910 TQ = 0
20920 FOR I = 1 TO NR%
20930 TQ = TQ + DQ(I)
20940 NEXT I
20950 PRINT "TOTAL DELIVERED SOIL": PRINT
20955 TQ = INT (10 * TQ + .5) / 10
20960 POKE 36,11: PRINT TQ;" TONS/YEAR": PRINT : PRINT : PRINT
20970 RETURN
20980 REM *****
20990 REM SUB:NITROGEN
21000 REM *****
21010 REM
21020 REM <<< GO SUB:NITROGEN(EROSION) >>>
21030 REM
21040 GOSUB 23160
21050 REM
21060 REM <<< GO SUB:NITROGEN(RAIN) >>>
21070 GOSUB 23370
21080 REM
21090 REM <<< GO SUB:TABLE(LU TOTAL NITROGEN) >>>
21100 REM
21110 GOSUB 23730
21120 REM
21130 REM <<< GO SUB:TABLE(SW TOTAL NITROGEN ) >>>

```

```

21140 GOSUB 23970
21150 REM
21155 A1 = 0
21160 REM <<< TOTAL NITROGEN >>>
21170 FOR I = 1 TO NR%
21180 A1 = A1 + NST(I)
21190 NEXT I
21200 TN = A1
21210 PRINT "TOTAL NITROGEN FORWATERSHED =";TN: PRINT
21215 PRINT : PRINT
21220 RETURN
21230 REM *****
21240 REM SUB:TABLE(SW AREA)
21250 REM *****
21260 PRINT : PRINT "XXX SUB-WATERSHED LAND USE AREAS XXX ": PRINT
21270 PRINT " UNIT= ACRES": PRINT
21280 PRINT "SW";: POKE 36,17: PRINT "FOREST";: POKE 36,28: PRINT "PA
STURE";: POKE 36,39: PRINT "HAYFIELD";: POKE 36,50: PRINT "CONV CROP";
: POKE 36,61: PRINT "MIN TILL";: POKE 36,72: PRINT "IDLE"
21290 FOR I = 1 TO NR%
21300 PRINT I;
21310 K1 = 7
21320 NU% = 6
21330 FOR J = 1 TO NU%
21340 K1 = K1 + 11
21350 POKE 36,K1: PRINT LAR(I,J);
21360 NEXT J
21370 PRINT
21380 NEXT I
21390 POKE 36,17: PRINT "LOW DEN";: POKE 36,28: PRINT "LOW/MED";: POK
E 36,39: PRINT "MED DEN";: POKE 36,50: PRINT "HIGH DEN";: POKE 36,61:
PRINT "COMMERCIAL"
21400 FOR I = 1 TO NR%
21420 K1 = 7
21430 FOR J = NU% + 1 TO NC%
21440 K1 = K1 + 11
21450 POKE 36,K1: PRINT LAR(I,J);
21460 NEXT J
21470 PRINT
21480 NEXT I
21485 PRINT : PRINT
21490 RETURN
21500 REM *****
21510 REM SUB:TABLE(SOIL LOSS)
21520 REM *****
21530 REM
21540 T1$ = "SOIL LOSS TABLE"
21550 REM
21560 REM <<< GO SUB:TABLE1 >>>
21570 REM
21580 FOR I = 1 TO NR%
21590 FOR J = 1 TO NU%
21600 UV(I,J) = INT (10 * SL(I,J) + .5) / 10
21610 NEXT J
21620 NEXT I
21630 GOSUB 21830
21640 RETURN
21650 REM *****
21660 REM <SUB:TABLE(DELIVERED SOIL) >>
21670 REM *****

```

```

21680 REM
21690 T1$ = "DELIVERED SOIL TABLE"
21700 REM
21710 REM <<< GO SUB:TABLE1 >>>
21720 REM
21730 FOR I = 1 TO NR%
21740 FOR J = 1 TO NU%
21750 UV(I,J) = INT (10 * DD(I,J) + .5) / 10
21760 NEXT J
21770 NEXT I
21780 GOSUB 21830
21790 RETURN
21800 REM *****
21810 REM SUB:TABLE:1
21820 REM *****
21830 HOME
21840 PRINT " ***** ";T1$;" *****": PRINT
21850 PRINT " (";U1$;" )": PRINT
21860 PRINT "SW";: POKE 36,17: PRINT "FOREST";: POKE 36,28: PRINT "PA
STURE";: POKE 36,39: PRINT "HAYFIELD";: POKE 36,50: PRINT "CONV CROP";
: POKE 36,61: PRINT "MIN TILL";: POKE 36,72: PRINT "IDLE"
21870 FOR I = 1 TO NR%
21880 PRINT I;
21890 K1 = 7
21900 FOR J = 1 TO NU%
21910 K1 = K1 + 11
21920 POKE 36,K1: PRINT UV(I,J);
21930 NEXT J
21940 PRINT
21950 NEXT I
21955 PRINT : PRINT
21960 RETURN
21970 REM *****
21980 REM SUB:TABLE(SW SOIL LOSS)
21990 REM *****
22000 REM
22010 T1$ = "SUB-WATERSHED SOIL LOSS "
22020 REM
22030 REM <<< GO SUB:TABLE2 >>>
22040 REM
22050 FOR I = 1 TO NR%
22060 UV(I,1) = INT (10 * SQ(I) + .5) / 10
22070 NEXT I
22080 GOSUB 22270
22090 RETURN
22100 REM *****
22110 REM SUB:TABLE(SW DELIVERED SOIL)
22120 REM *****
22130 REM
22140 REM <<< GO SUB:TABLE2 >>>
22150 T1$ = "SUB-WATERSHED DELIVERED SOIL "
22160 REM
22170 REM <<< GO SUB:TABLE2 >>>
22180 U1$ = "TONS/YEAR"
22190 FOR I = 1 TO NR%
22200 UV(I,1) = INT (10 * DQ(I) + .5) / 10
22210 NEXT I
22220 GOSUB 22270
22230 RETURN
22240 REM *****

```



```

22250 REM SUB:TABLE2
22260 REM *****
22270 HOME
22280 PRINT " ***** ";T1$;" *****": PRINT
22290 PRINT "SUB-WATERSHED",U1$: PRINT
22300 FOR I = 1 TO NR%
22310 POKE 36,12: PRINT I;: POKE 36,32: PRINT UV(I,1)
22320 NEXT I
22325 PRINT : PRINT
22330 RETURN
22340 REM *****
22350 REM SUB:LAND USE
22360 REM *****
22370 REM
22380 REM <<<TOTAL SOIL LOSS BY LAND USE >>>
22390 REM
22400 REM <<< TONS/YEAR >>>
22410 FOR J = 1 TO NU%
22420 A1 = 0
22430 FOR I = 1 TO NR%
22440 A1 = A1 + SL(I,J)
22450 NEXT I
22460 LL(J) = A1
22470 NEXT J
22480 REM
22490 REM <<< GO SUB:TABLE(LU SOIL LOSS ) >>>
22500 REM
22510 GOSUB 22740
22520 REM
22530 REM <<< TOTAL DELIVERED SOIL BY LAND USE >>>
22540 REM
22550 REM
22560 REM <<< TONS/YEAR >>>
22570 REM
22580 FOR J = 1 TO NU%
22590 A1 = 0
22600 FOR I = 1 TO NR%
22610 A1 = A1 + DD(I,J)
22620 NEXT I
22630 LD(J) = A1
22640 NEXT J
22650 REM
22660 REM <<< GO SUB:TABLE(LU DELIVERED SOIL) >>>
22670 REM
22680 GOSUB 23010
22690 RETURN
22700 REM *****
22710 REM SUB:TABLE(LU SOIL LOSS)
22720 REM *****
22730 REM
22740 T3$ = "TOTAL SOIL LOSS BY LAND USE"
22750 REM
22760 REM <<< GO SUB:TABLE3 >>>
22770 REM
22780 FOR J = 1 TO NU%
22790 UV(1,J) = INT (10 * LL(J) + .5) / 10
22800 NEXT J
22810 GOSUB 22860
22820 RETURN
22830 REM *****

```

```

22840 REM SUB:TABLE3
22850 REM *****
22860 HOME
22870 PRINT " T3$ ";T3$;" T3$"; PRINT
22880 PRINT SPC( 10);U1$: PRINT
22890 FOR J = 1 TO NU%
22900 PRINT SW$(J);" = ";UV(1,J)
22910 NEXT J
22920 PRINT
22925 PRINT : PRINT
22930 RETURN
22940 REM *****
22950 REM SUB:(TABLE(LU SOIL DELIVERED)
22960 REM *****
22970 REM
22980 REM
22990 REM <<< GO SUB:TABLE3 >>>
23000 REM
23010 T3$ = "TOTAL DELIVERED SOIL BY LAND USE"
23020 U3$ = "TONS/YEAR"
23030 FOR J = 1 TO NU%
23040 UV(1,J) = INT (10 * LD(J) + .5) / 10
23050 NEXT J
23060 GOSUB 22860
23070 RETURN
23080 REM *****
23090 REM SUB:NITROGEN(EROSION)
23100 REM *****
23110 REM
23120 REM <<< BY LAND USE >>>
23130 REM
23140 REM <<< POUNDS/YEAR >>>
23150 REM
23160 AD = 20
23170 FOR J = 1 TO NU%
23180 NLE(J) = AD * LD(J) * RC(1) * RC(2)
23190 NEXT J
23200 REM
23210 REM <<< BY SUB-WATERSHED >>>
23220 REM
23230 REM <<< POUNDS/YEAR >>>
23240 REM
23250 FOR I = 1 TO NR%
23260 NWS(I) = AD * DQ(I) * RC(1) * RC(2)
23270 NEXT I
23280 RETURN
23290 REM *****
23300 REM SUB:NITROGEN(RAIN)
23310 REM *****
23320 REM
23330 REM <<< BY LAND USE >>>
23340 REM
23350 REM <<< POUNDS/YEAR >>>
23360 REM
23370 AD = 20:B1 = .75
23380 REM
23390 REM <<< FIND LAND USE AREAS >>>
23400 REM
23410 FOR J = 1 TO NU%
23420 A1 = 0

```

```

23430 FOR I = 1 TO NR%
23440 A1 = A1 + LAR(I,J)
23450 NEXT I
23460 LU(J) = A1
23470 NEXT J
23480 FOR J = 1 TO NU%
23490 NQR(J) = LU(J) * RC(3) * RC(4) * .75 / RC(5)
23500 NEXT J
23510 REM
23520 REM <<< BY SUB-WATERSHED >>>
23530 REM
23540 REM <<< POUNDS/YEAR >>>
23550 REM
23560 REM <<< FIND SUB-WATERSHED AREAS >>>
23570 FOR I = 1 TO NR%
23580 A1 = 0
23590 FOR J = 1 TO NU%
23600 A1 = A1 + LAR(I,J)
23610 NEXT J
23620 LW(I) = A1
23630 NEXT I
23640 FOR I = 1 TO NR%
23650 NPR(I) = LW(I) * RC(3) * RC(4) * .75 / RC(5)
23660 NEXT I
23670 RETURN
23680 REM *****
23690 REM SUB:TABLE(LU TOTAL NITROGEN)
23700 REM *****
23710 REM
23720 REM <<< FIND TOTAL NITROGEN BY LAND USE >>>
23730 FOR J = 1 TO NU%
23740 NTL(J) = NLE(J) * RC(6) * NQR(J)
23750 NEXT J
23760 REM <<< GO SUB:TABLE4 >>>
23770 T4$ = "TOTAL NITROGEN BY LAND USE"
23780 U4$ = "POUNDS/YEAR"
23790 GOSUB 23850
23810 RETURN
23820 REM *****
23830 REM SUB:TABLE 4
23840 REM *****
23850 PRINT "XXX ";T4$;" XXX": PRINT
23860 PRINT "UNITS= ";U4$: PRINT
23870 PRINT "LAND USE";: POKE 36,32: PRINT "TOTAL NITROGEN"
23880 FOR J = 1 TO NU%
23885 NTL(J) = INT (10 * NTL(J) + .5) / 10
23890 PRINT SW$(J);: POKE 36,37: PRINT NTL(J)
23900 NEXT J
23905 PRINT : PRINT
23910 RETURN
23920 REM *****
23930 REM SUB:TABLE(SW TOTAL NITROGEN)
23940 REM *****
23950 REM
23960 REM <<< FIND TOTAL NITROGEN BY SUB-WATERSHED >>>
23970 FOR I = 1 TO NR%
23980 NST(I) = NWS(I) * RC(6) * NPR(I)
23990 NEXT I
24000 REM
24010 REM <<< GO SUB:TABLE5 >>>

```

```

24020 REM
24030 T5$ = "TOTAL NITROGEN BY SUB-WATERSHED"
24040 U5$ = "POUNDS/YEAR"
24050 GOSUB 24100
24060 RETURN
24070 REM *****
24080 REM SUB:TABLE5
24090 REM *****
24100 PRINT "### ";T5$;" ###": PRINT
24110 PRINT "UNITS = ";U4$: PRINT
24120 PRINT "SUB-WATERSHED";: POKE 36,32: PRINT "TOTAL NITROGEN "
24130 FOR I = 1 TO NR%
24135 NST(I) = INT (10 * NST(I) - .5) / 10
24140 PRINT " ";I;: POKE 36,37: PRINT NST(I)
24150 NEXT I
24160 PRINT
24170 RETURN
24180 REM *****
24190 REM * SUB:PHOSPHOROUS *
24200 REM *****
24210 REM
24220 REM
24230 REM <<< BY LAND USE >>>
24240 REM
24250 REM <<< POUNDS/YEAR >>>
24260 REM
24270 AD = 20
24280 FOR J = 1 TO NU%
24290 PL(J) = AD * LD(J) * PC(1) * PC(2) * PC(3)
24300 NEXT J
24310 REM
24320 REM <<< BY SUB-WATERSHED >>>
24330 REM
24340 FOR I = 1 TO NR%
24350 PW(I) = AD * DQ(I) * PC(1) * PC(2) * PC(3)
24360 NEXT I
24370 REM
24380 REM <<< PRINT TABLES >>>
24390 REM
24400 REM
24410 REM <<< GOSUB:TABLE(LU TOTAL PHOSPHOROUS )
24420 REM
24430 GOSUB 24550
24440 REM
24450 REM <<< GOSUB: TABE(SW TOTAL PHOSPHOROUS )
24460 REM
24470 GOSUB 24750
24472 REM <<< TOTAL PHOSPHOROUS >>>
24474 A1 = 0
24476 FOR I = 1 TO NR%
24478 A1 = A1 + PW(I)
24480 NEXT I
24482 TP = A1
24484 PRINT "TOTAL PHOSPHOROUS FOR WATERSHED = ";TP: PRINT : PRINT :
PRINT
24486 RETURN
24490 REM *****
24500 REM * SUB:TABLE(LU TOTAL PHOSPHOROUS )
24510 REM *****
24520 REM

```

```

24530 REM    <<< GOSUB:TABLE 6 >>>
24540 REM
24550 T6$ = "TOTAL PHOSPHOROUS BY LAND USE"
24560 U6$ = "POUNDS/YEAR"
24570 GOSUB 24620
24580 RETURN
24590 REM  *****
24600 REM  * SUB:TABLE 6 *
24610 REM  *****
24620 PRINT "XXX";T6$;" XXX": PRINT
24630 PRINT "UNITS = ";U6$: PRINT
24640 PRINT "LAND USE";: POKE 36,32: PRINT "TOTAL PHOSPHOROUS"
24650 FOR J = 1 TO NU%
24655 PL(J) = INT (10 * PL(J) + .5) / 10
24660 PRINT SW$(J);: POKE 36,37: PRINT PL(J)
24670 NEXT J
24675 PRINT : PRINT
24680 RETURN
24690 REM  *****
24700 REM  * SUB: TABLE( SW TOTAL PHOSPHOROUS )
24710 REM  *****
24720 REM
24730 REM    <<< GOSUB: TABLE 7 >>>
24740 REM
24750 T7$ = "TOTAL PHOSPHOROUS BY SUB-WATERSHED "
24760 U7$ = "POUNDS/YEAR"
24770 GOSUB 24820
24780 RETURN
24790 REM  *****
24800 REM  * SUB: TABLE 7 *
24810 REM  *****
24820 PRINT "XXX";T7$;" XXX": PRINT
24830 PRINT "UNITS = ";U7$: PRINT
24840 PRINT "SUB-WATERSHED";: POKE 36,32: PRINT "TOTAL PHOSPHOROUS"
24850 FOR I = 1 TO NR%
24855 PW(I) = INT (10 * PW(I) + .5) / 10
24860 PRINT I;: POKE 36,37: PRINT PW(I)
24870 NEXT I
24875 PRINT : PRINT
24880 RETURN
24890 REM  *****
24900 REM  * SUB: ORGANIC MATTER *
24910 REM  *****
24920 REM
24930 REM
24940 REM    <<< BY LAND USE >>>
24950 REM
24960 REM    <<< POUNDS/YEAR >>>
24970 REM
24980 AD = 20
24990 FOR J = 1 TO NU%
25000 ML(J) = AD * LD(J) * OM(1) * OM(2)
25010 NEXT J
25020 REM
25030 REM    <<< BY SUB-WATERSHED >>>
25040 REM
25050 FOR I = 1 TO NR%
25060 MW(I) = AD * DQ(I) * OM(1) * OM(2)
25070 NEXT I
25080 REM

```

```

25090 REM      <<< PRINT TABLES >>>
25100 REM
25110 REM
25120 REM      <<< GOSUB: TABLE(LU ORGANIC MATTER) >>>
25130 REM
25140 GOSUB 25260
25150 REM
25160 REM      <<< GOSUB: TABLE(SW ORGANIC MATTER )
25170 REM
25180 GOSUB 25450
25182 REM <<< TOTAL ORGANIC MATTER FOR SUBWATERSHED >>>
25184 A1 = 0
25186 FOR I = 1 TO NR%
25188 A1 = A1 + MW(I)
25190 NEXT I
25192 TR = A1
25194 PRINT "TOTAL ORGANIC MATTER FOR WATERSHED = ";TR: PRINT : PRINT
: PRINT
25196 RETURN
25200 REM *****
25210 REM * SUB:TABLE(LU ORGANIC MATTER ) *
25220 REM *****
25230 REM
25240 REM      <<< GOSUB:TABLE 8 >>>
25250 REM
25260 T8$ = "TOTAL ORGANIC MATTER BY LAND USE"
25270 U8$ = "POUNDS/YEAR"
25280 GOSUB 25330
25290 RETURN
25300 REM *****
25310 REM * SUB:TABLE 8 *
25320 REM *****
25330 PRINT "XXX";T8$;" XXX": PRINT
25340 PRINT "UNITS = ";U8$: PRINT
25350 PRINT "LAND USE";: POKE 36,32: PRINT " TOTAL ORGANIC MATTER"
25360 FOR J = 1 TO NU%
25363 OL(J) = INT (10 * OL(J) + .5) / 10
25365 ML(J) = INT (10 * ML(J) + .5) / 10
25370 PRINT SW$(J);: POKE 36,27: PRINT ML(J)
25380 NEXT J
25386 PRINT : PRINT
25387 RETURN
25390 REM *****
25400 REM * SUB:TABLE(SW TOTAL ORGANIC MATTER) *
25410 REM *****
25420 REM
25430 REM      <<< GOSUB:TABLE 9 >>>
25440 REM
25450 T9$ = "TOTAL ORGANIC MATTER BY SUB-WATERSHED"
25460 U9$ = "POUNDS/YEAR"
25470 GOSUB 25530
25490 RETURN
25500 REM *****
25510 REM * SUB: TABLE 9 *
25520 REM *****
25530 PRINT "XXX";T9$;" XXX": PRINT
25540 PRINT "UNITS = ";U9$: PRINT
25550 PRINT "SUB-WATERSHED";: POKE 36,32: PRINT "TOTAL ORGANICMATTER"

25560 FOR I = 1 TO NR%

```

```

25565 MW(I) = INT (10 * MW(I) + .5) / 10
25570 PRINT I;: POKE 36,37: PRINT MW(I)
25580 NEXT I
25585 PRINT : PRINT
25590 RETURN
25600 REM *****
25610 REM * SUB: LOADING FACTOR CALCULATIONS *
25620 REM *****
25625 REM
25630 REM <<< BY LAND USE AND SUBWATERSHED >>>
25632 REM
25634 GOSUB 26506
25636 REM
25640 REM <<< BY LAND USE >>>
25650 REM
25660 REM CALCULATE POLLUTANT LOADINGS
25670 REM
25680 FOR M = 1 TO 6
25690 FOR J = 1 TO NC%
25700 TA = 0
25710 FOR I = 1 TO NR%
25720 TA = TA + LAR(I,J)
25730 NEXT I
25740 PM(M,J) = HF(M,J) * TA
25750 NEXT J
25760 NEXT M
25770 REM
25780 REM PRINT POLLUTANT LOAD FOR EACH LAND USE
25790 REM
25800 PRINT "%% POLLUTANT LOADS USING LOADING FACTORS %%": PRINT :
PRINT
25810 PRINT " BY LAND USE (POUNDS/YEAR)": PRINT
25820 FOR M = 1 TO 6
25830 PRINT LF$(M);" : ": PRINT
25840 POKE 36,17: PRINT "FOREST";: POKE 36,28: PRINT "PASTURE";: POKE
36,39: PRINT "HAYFIELD";: POKE 36,50: PRINT "CONV CROP";: POKE 36,61:
PRINT "MIN TILL";: POKE 36,72: PRINT "IDLE"
25850 NU% = 6
25860 K1 = 7
25880 FOR J = 1 TO NU%
25883 K1 = K1 + 11
25885 PM(M,J) = INT (10 * PM(M,J) + .5) / 10
25890 POKE 36,K1: PRINT PM(M,J);
25910 NEXT J
25920 PRINT
25930 NEXT J
25940 POKE 36,17: PRINT "LOW DEN";: POKE 36,28: PRINT "LOW/MED";: POK
E 36,39: PRINT "MED DEN";: POKE 36,50: PRINT "HIGH DEN";: POKE 36,61:
PRINT "COMMERCIAL"
25950 K1 = 7
25960 FOR J = NU% + 1 TO NC%
25962 K1 = K1 + 11
25965 PM(M,J) = INT (10 * PM(M,J) + .5) / 10
25970 POKE 36,K1: PRINT PM(M,J);
25980 K1 = K1 + 11
26000 NEXT J
26010 PRINT
26020 NEXT M
26025 PRINT
26030 REM

```

```

26040 REM      <<< BY SUB-WATERSHED >>>
26050 REM
26060 REM
26070 REM      CALCULATE POLLUTANT LOADING
26080 REM
26090 FOR I = 1 TO NR%
26100 FOR M = 1 TO 6
26110 PJ = 0
26120 FOR J = 1 TO NC%
26130 PJ = PJ + HF(M,J) * LAR(I,J)
26140 NEXT J
26145 PI(I,M) = PJ
26150 NEXT M
26160 NEXT I
26170 REM
26180 REM      PRINT POLLUTANT LOADS FOR EACH SUB-WATERSHED
26190 REM
26210 PRINT "BY SUBWATERSHED          (POUNDS/YEAR)": PRINT
26220 FOR I = 1 TO NR%
26230 PRINT "SUBWATERSHED ";I: PRINT
26240 FOR M = 1 TO 6
26245 PI(I,M) = INT (10 * PI(I,M) + .5) / 10
26250 PRINT "      ";LF$(M);: POKE 36,33: PRINT PI(I,M)
26260 NEXT M
26270 PRINT
26280 NEXT I
26290 RETURN
26500 REM *****
26502 REM * SUB: BY LAND USE AND SUBWATERSHED *
26504 REM *****
26506 PRINT "*** POLLUTANT LOADS USING LOADING FACTORS ***": PRINT :
PRINT
26508 PRINT "BY LAND USE AND SUBWATERSHED          (POUNDS/ACRE)": PRINT

26510 FOR M = 1 TO 6
26512 PRINT LF$(M);" : ": PRINT
26515 FOR I = 1 TO NR%
26517 PRINT "      SW: ";I: PRINT
26520 FOR J = 1 TO NC%
26525 PA(J) = HF(M,J) * LAR(I,J)
26530 NEXT J
26540 POKE 36,17: PRINT "FOREST";: POKE 36,28: PRINT "PASTURE";: POKE
36,39: PRINT "HAYFIELD";: POKE 36,50: PRINT "CONV CROP";: POKE 36,61:
PRINT "MIN TILL";: POKE 36,72: PRINT "IDLE"
26550 NU% = 6
26555 K1 = 7
26560 FOR J = 1 TO NU%
26565 K1 = K1 + 11
26570 PA(J) = INT (10 * PA(J) + .5) / 10
26575 POKE 36,K1: PRINT PA(J);
26580 NEXT J
26585 PRINT
26590 POKE 36,17: PRINT "LOW DEN";: POKE 36,28: PRINT "LOW/MED";: POK
E 36,39: PRINT "MED DEN";: POKE 36,50: PRINT "HIGH DEN ";: POKE 36,61:
PRINT "COMMERCIAL"
26595 K1 = 7
26600 FOR J = NU% + 1 TO NC%
26605 K1 = K1 + 11
26610 PA(J) = INT (10 * PA(J) + .5) / 10
26615 POKE 36,K1: PRINT PA(J);

```


26620 NEXT J
26625 PRINT
26630 NEXT I
26635 NEXT M
26640 RETURN

NOAA COASTAL SERVICES CENTER LIBRARY



3 6668 14103 6097